Essays on Culture and Economic Relationships

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Arthur Blouin
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Declaration

I declare that any material contained in this thesis has not been submitted for a degree to any other university. I further declare that one chapter from this thesis (chapter 3) is coauthored with Dr. Rocco Macchiavello.

Arthur Blouin

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Author List

The following authors contributed to Chapter 1: Arthur Blouin

The following authors contributed to Chapter 2: Arthur Blouin

The following authors contributed to Chapter 3: Arthur Blouin, Rocco Macchiavello

The following authors contributed to Chapter 4: Arthur Blouin

The following authors contributed to Chapter 5: Arthur Blouin

Thesis advisors: Sharun Mukand, Rocco Macchiavello Arthur Blouin

Essays on Culture and Economic Relationships

Abstract

Chapter two investigates whether insular cultures are less likely to adopt new technologies. Combining GIS crop production data with unique language data, I show that societies that are isolated on the language tree produce less of the crops that required adoption, but not of the crops not requiring adoption. Endogeneity of cultural isolation is addressed by exploiting ancestral migration route direction. Cultural isolation persists due to the endogeneity of land settlement. Land selection caused increased polarization and decreased fractionalization, a pattern that is argued to limit the incentives for cross-societal communication.

Chapter three uses contract level data on a portfolio of 197 coffee washing stations in 18 countries to identify the sources and consequences of credit imperfections. Due to moral hazard, default increases following increases in world coffee prices just before the maturity date of the contract. Strategic default is deterred by relationships with the lender and foreign buyers: the value of informal enforcement amounts to 50% of the value of the sale contract for repaying borrowers. A RDD shows that firms are credit constrained. Prices paid to farmers increase implying the existence of contractual externalities along the supply chain.

Chapter four analyzes the effect of interethnic trust on economic relationships in Rwanda/Burundi. The endogeneity of defaults impact on trust is dealt with by exploiting the eligibility of respondents' grandparents to coffee corvée in the colonial era. Corvée contributed to Hutu-Tutsi tensions. Corvée eligibility is used as an exogenous instrument for interethnic trust, measured using a unique dataset collected in the field. Grandparent eligibility for corvée reduces interethnic trust, and that low trust increases the likelihood of being defaulted on. The evidence suggests that default becomes more likely among less trusting individuals due to adverse selection, not moral hazard.

1

Introduction

Economic relationships drive economic development. They form out of, and interact with almost all environmental factors, and the nature of relationships differ depending on context. Cultural norms both cause, and are caused by economic relationships; the relationship is incredibly complex. When economic relationships fail development breaks down, and therefore cultural inefficiencies can have powerful effects.

Culture, in many cases, seems far more slowly moving than most economic outcomes. While it may respond rationally to context, the updating process takes time. Furthermore, in some cases, cultural equilibria can form which may be suboptimal. Because of these phenomena it is difficult to overstate the importance of economic history. History shapes culture, influences economic relationships in numerous ways, which in turn determines development. This thesis is about that process.

The second chapter looks at insular cultures, and their propensity to adopt new technologies. Technology adoption is a fundamental aspect of driving development, and has been the most prominent feature of leading growth models over the past few decades. The chapter outlines how insular cultures are less able to adopt agricultural crops for historical reasons. It tracks one tribe, the Bantu, from their origins along the

Nigeria-Cameroon border at the beginning of the first millennium. It shows how the migration process shaped cultural isolation through skill development, and how the effect persisted for over 500 years after the settlement process had ended in 1500C.E.

The migration process followed two distinct branches, one travelling through the rainforest, and the other travelling around it. Because the group that went through the rainforest had a much more specialized type of agriculture and hunting/fishing, they communicated less with other tribes around them. This happened generation after generation until they emerged from the rainforest 1,000 years later. At that point cultures were very inward looking for those whose ancestors lived in the rainforest; much more so than those whose ancestors travelled around it. Both groups ended up living in the same regions in southern Africa by the end of the settlement process, but the cultural divergence that took place impacted economic success.

The cultural change had important economic consequences that impacted the long run economic success of much of southern Africa. First, during the initial settlement of southern Africa, the two migration branches preferred different types of land. The group whose ancestors lived in the rainforest preferred to settle on land similar to the rainforest, because they no longer knew how to produce in a non-rainforest environment. This knowledge was not passed down to them by their ancestors because in the rainforest it was not important. The land selection process influenced tribal neighbours. The rainforest group travelled farther from the main migration branch to find the land they wanted, and as a result ended up with fewer tribal neighbours, and the neighbours they did have were much more different from them.

This made communication much more difficult for the already more insular ancestors of rainforest migrants. With low levels of communication, observation of new agricultural techniques were lower, and experimentation with new 'technologies' was lower as well. This reduced technological adoption, which became especially important during the slave trade.

With the large influx of western travel to southern Africa in the late 16th century, a host of new agricultural technologies were introduced to the region. Among the most important were the introduction of maize and wheat, which were highly suitable to the African climate, but were not native to the region. The adoption of these crops occurred quickly, but adoption was not uniform. The rainforest migrants, who communicated less with neighbours and experimented less with new methods of production were also less likely to adopt the new and profitable crops. Over time the reduced profitability in agriculture in these regions caused a shift away from

agricultural production and into different industries. The low rates of adoption persisted until today. There is still less production of all crops introduced during the slave trade in regions settled by the descendants of rainforest habitants. This is true despite the fact that many of the new crops were highly suitable for a rainforest environment, crops like sunflower, groundnut and sugarcane. This is only one example of how culture influences economic productivity through economic interactions, or a lack thereof.

The third chapter focuses more specifically on how and when economic relationships can break down, and acts as a bridge to the fourth chapter, which deals specifically with the interaction between culture and the breakdown of economic relationships. The focus of the third chapter is contractual default in the coffee industry. The chapter, coauthored with Dr. Rocco Macchiavello, discusses the reasons and consequences of contractual default. It follows the clients of a particular lending agent, who lends to the coffee sector around the world. We find evidence that clients default on contracts when it is most profitable for them to delay repayment, and show that these clients are more credit constrained, as implied by the higher levels of default.

The impact of default on economic relationships has a much larger impact than may seem obvious at first glance. High defaults mean that lenders will be more careful with their money, and will risk less than they may in a world with lower default. Loans are to processing stations, who buy coffee cherries from farmers. When the processing stations receive lower loan amounts the price that the farmers receive for cherries decreases. So default by one processing station negatively impacts not only other processing stations, but other farmers as well.

Default is clearly related to the strength of the economic relationship. Default is not going to happen in a strong economic relationship, because the risk of ending the relationship is too great. This point comes through in the data. Firms with lower valuations of their relationship with the lender are more likely to default, highlighting the importance of relationships for the economic development of a region.

Economic relationships are clearly not created randomly. Both chapters two and three show that economic relationships are incredibly important for economic success. While chapter two touches on insular cultures, and how they arise, the more macro based approach doesn't allow for the in depth analysis of any particular relationship. Chapter three addresses the impacts of a single relationship type, but addressing the origins and development of the relationship value which is crucial to

the analysis is beyond the scope of the chapter.

The fourth chapter is a micro level analysis of the cultural development of economic relationships, as well as the economic outcomes. It draws on field research of farmers in Rwanda and Burundi. The analysis is framed around the historical encouragement of forced labour by Belgian colonists in the colonial nation of RwandaUrundi. In the colonial era, the Hutu and Twa were subjected to forced labour by the ruling Tutsi so that Tutsi could meet the strict coffee quotas imposed by the Belgians. The forced labour was considered a humiliation, and sparked the long term resentment between the Hutu and the Tutsi in the region.

I surveyed Hutu, Tutsi and Twa farmers in regions where forced labour (corvée) existed and where it didn't, and I show that interethnic trust is at least in part determined by the historical policy, and I show the consequences that this trust has on contractual outcomes. Farmers that have lower interethnic trust experience more default than those with high interethnic trust.

I show that it is low trust that causes farmers to be defaulted on and not that being defaulted on causes low trust, which would be an equally plausible explanation. At the time, whether someone was chosen into corvée was plausibly random. It had to do with the land quality, specifically the suitability of the land to coffee, however this was at a time when there was nearly no coffee being produced, so very few farmers cared about how suitable their land was to coffee. Furthermore, only in areas where coffee was not the most profitable crop was corvée encouraged. Because of this I can compare regions where coffee was very close to being the most profitable crop but wasn't to regions where coffee was very close to not being the most profitable crop, but was. As the relative profitability of other crops to coffee increased, the use of corvée increased - as long as coffee wasn't profitable.

The fourth chapter therefore pulls elements from the other two, by highlighting the importance of culture, through interethnic trust, as well as the importance of economic relationships on development. It does this in a way that tracks culture back to its historic roots, and shows specifically how and why it impacts development. Here, I show that contractual default arises from low trust through its impact on the quality of business partner, rather than due to the general interest level of business partners. This is a somewhat surprising result. Many may have thought that if people with low interethnic trust were defaulted on more, it would be because of a reduced motivation to do business with that type of person, but there is no evidence to support this information. Instead, the evidence shows that Hutu with low Tutsi trust

habitually substitute out of business relationships with higher ability Tutsi partners and do business instead with lower ability Hutu partners. The lower ability Hutu partners are more likely to default.

The thesis, I hope, presents some interesting results that highlight the importance of culture, and specifically how it interacts with long term relationships to shape economic development. The work in this area is growing, but is far from complete. For me, the work has opened as many questions as it has answered, and has increased my awareness of future work in the area that needs to be done. Future projects that have arisen from this work are described in the conclusion.

2

The Cultural Transmission of Knowledge: Evidence from the Bantu Expansion

2.1 Introduction

Technology has long been considered crucial to explaining differences in living standards and economic growth (Solow (1956)). Because of this, there is a long literature studying technology adoption between societies. One 'central puzzle' in this literature is why information does not diffuse between countries or societies faster and more completely than it does (Spolaore and Wacziarg (2012)).

In this paper we exploit one of history's largest migration episodes–the Bantu expansion–to make three contributions to our understanding of between-society information diffusion[1]. First, we test the Diamond (1998) technology hypothesis:

[1]The idea that technologies are more easily transmitted within groups than between groups has been studied before. Conley and Udry (2008) experiment with Ghanaian farmers and show inputs

north-south axis orientation impairs information diffusion[2]. Second, we show that this diffusion failure does not immediately recover once information is made available[3]. This is surprising, as it would have been reasonable to expect, both from the logical implications of Diamond's hypothesis and from the broader literature on between-society technology diffusion, that information availability was the key constraint. Third though, we show that among the Bantu, larger cultural barriers are associated with an ancestral north-south migration axis, and this additional cost to acquiring information can account for up to a 35% reduction in current agricultural productivity.

The Bantu expansion was one of the largest ever human migration movements. Migration began near what is now the Nigeria/Cameroon border, and followed two primary routes - south and east. Over many generations of migration large differences in the suitability of dry crops emerged, as the southern branch migrated through the rainforest in central Africa. This lends itself well to the study of the Diamond (1998) axis-orientation hypothesis which suggested that information travelled more efficiently along an east-west axis than along a north-south axis. This is because along a north-south axis there is less benefit to learning from neighbouring communities, since the likelihood of two societies sharing similar agro-climactic conditions is lower.

The typical challenge with studying this hypothesis is that it is difficult to separate

change with the inputs of 'information neighbours', conditional on being geographic neighbours. Also, Sanchez-Burks et al. (2003) shows the vertical transmission of culture from parents to children with respect to how literally messages are received. One paper by Algan et al. (2012) show that both horizontal and vertical transmission of culture are important in baby naming conventions in France.

[2]A paper by Olsson and Hibbs (2005) also study Diamond's hypothesis by looking at the correlation between biogeographic factors and productivity

[3]Analyzing the effect of history on culture is now a pretty mature literature. Nunn (2008) and Nunn and Wantchekon (2012), for example, show the long run effects of the slave trade and identify the impact on trust as being particularly important in persistence and Alesina et al. (2011) show that the introduction of the plough caused decreases in women's rights. Other related works include Cohen et al. (1996), for example, show that a culture of honour in America is related to historic herding rather than farming and Becker et al. (2010) show that better historical institutions can lead to higher trust.

between the direct effect of agro-climactic conditions on technology decisions and the information effect associated with axis-orientation. In this sense the Bantu context is ideal. The north-south migrants went directly south, through the rainforest but the east-west migrants went east until they reached the east coast of Africa, then they went south, migrating around the rainforest. Both the east-west and north-south migration branches rejoined after 1000C.E., and currently live in the same regions in some parts of southern Africa. This allows us to test the spirit of the Diamond (1998) hypothesis, as agro-climactic conditions in the rainforest are much more diverse than outside the rainforest. But, we don't have to deal with the problem of comparing communities in much different agricultural environments. Because of this we focus on cropping patterns in southern Africa, the region where the descendants of the southern and eastern migrants now live in nearby communities, with access to the same types of land and the same information from neighbours.

To study this we construct a new dataset, bringing together many types of data from several different sources. They include: (1) a newly constructed dataset on Bantu language evolution, which is used to assign migration routes to ethno-linguistic groups[4], and to construct a measure of language barriers[5]. (2) Settlement locations are taken from a tribal map of Africa (Murdock (1959)). The matched language, settlement and migration data is then matched to (3) GIS crop data which provides current crop production for each crop in Africa. (4) Historical land use data, which is a panel estimating the allocation of each piece of land in Africa to either crops, pasture or urban land. This is then joined with (5) and (6), historical population panel datasets from two independent sources. And finally these 6 data sources are matched

[4]The Bantu language tree contains a partition, which is analogous to the east-south migration division, so groups with a 'southern Bantu' language are assumed to have followed a southern migration route.

[5]Desmet et al. (2011) also use language tree data to examine the cultural distance between various societies

to (7) crop suitability data from the FAO, which provides the suitability of each piece of land for each crop.

The richness of this dataset allows us to analyze information diffusion in a number of different ways. In each of our empirical strategies we compare the descendants of southern and eastern migrating Bantu, and therefore make the identifying assumption that the initial ancestral decision to migrate east or south is orthogonal to current cropping decisions. There are two reasons that make this assumptions reasonable. First, migration speed was so slow that for any single leg of migration there were no substantial differences in land characteristics, so migrants simply went where land was abundant (Vansina (1990)). Second, the crop decisions analyzed here take place hundreds of years after the original migration decision took place, so any small differences in comparative advantage that may have existed are very unlikely to remain relevant.

After checking the validity of this assumption, we use it to test three main hypotheses. We start by documenting that axis-orientation mattered for information flows. We demonstrate this in two ways. First, we look at migration patterns as groups entered and exited the rainforest. We interpret differences in migration speed at the migration frontier as differences in agricultural productivity[6], and show a drop in migration speed as migrants both entered and exited the rainforest, indicating that the same agricultural techniques that were previously useful, are no longer generating the same levels of success. This suggests that productivity decreased for the types of crops that are suited to both the Bantu homeland and southern Africa but not the rainforest. This is consistent with the axis-orientation hypothesis, but as migration speeds are an imperfect proxy for agricultural production, this can only be considered as suggestive evidence that axis orientation matters for information diffusion.

[6]This is standard practice when considering populations facing Malthusian conditions (Ashraf and Galor (2011a)).

We then show similar trends for a more direct measure of information: land devoted to livestock. Livestock was kept in the Bantu homeland, was not productive in the rainforest because of the tsetse fly, and then was able to be kept again in southern Africa. It is straightforward to examine whether livestock knowledge survived rainforest migration. We find that after settlement in southern Africa, less land was devoted to livestock by the north-south migrants. We can look at the dynamics of the re-acquisition of livestock knowledge as well. We find no evidence supporting the historical reacquisition of any livestock knowledge. We therefore investigate the possibility that axis-orientation can lead to a permanent decrease in information acquisition.

The permanence of the axis-orientation effect depends, at least in part, on the endogeneity of the costs of information acquisition (e.g. language barriers, geographic isolation). It may be that cultural drift is greater along a north-south axis since as the potential benefit to sharing and acquiring information is reduced, there should be less interaction between neighbouring societies.

We begin to investigate the possibility that axis-orientation permanently reduced information acquisition by looking at current differences between dry and wet crops that are traditional to Africa. The idea behind this strategy is that dry-crops were produced in the Bantu homeland and in southern Africa, but information on how to produce them may have been lost in the rainforest where they could not be produced. Since we have very detailed data on crop production, by crop, we can rule out several alternate hypotheses by using wet-crop production as a falsification test. We find that every dry crop that is traditional to Africa is less produced by communities with a north-south migration ancestry relative to those with an east-west ancestry. However, *none* of the wet crops traditional to Africa are similarly less produced by descendants of north-south migrants.

Concerned that this might be due to a comparative advantage for wet-crop production, we also examine the crops introduced through the slave trade. All New World crops, wet and dry, had to be acquired by both groups of migrants. So unlike with the traditional African crops where we expect only dry-crops to have been affected, with New World crops both wet and dry crops should be less produced by north-south migrant descendants. Indeed, this is what we find - all New World crops, wet or dry, are less produced by descendants of rainforest migrants indicating that these communities are systematically acquiring less agricultural information than communities with an east-west heritage.

Qualitative research suggests that this might be true for the Bantu because of increased cultural barriers faced by those with a rainforest heritage (Guthrie (1948)). Empirical evidence also suggests that variability in land characteristics can cause ethnolinguistic diversity (Michalopoulos (2011))[7]. We might consider these cultural barriers as similar to a non-economic cost to acquiring new information, even when information availability ceases to be the dominant constraint.

Following this logic it should be true that a north-south migration axis is associated with more cultural drift. We show, in a number of ways, that this is true for the Bantu. First, using a new measure of linguistic isolation based on language tree data, we show that linguistic isolation is much greater for descendants of north-south migrants. We can confirm using non-language societal characteristics, that the north-south group differs on isolation based characteristics, but not characteristics that are unrelated to isolation.

[7] Ashraf and Galor (2011b) also study the origins of diversity. Relatedly, the work is contributes to the consequences of diversity. The literature starts with a seminal work by Easterly and Levine (1997) who show that racial fractionalization is negatively correlated with growth in cross-country regressions. Collier and Gunning (1999) follow-up on the work, arguing that linguistic fractionalization causes low social capital and less provision of public goods which limits the growth of nations. Alesina et al. (2003) confirm results from both papers using more sophisticated and complete data. Much of the literature has focused on public good provision, or other forms of institutional quality. LaPorta et al. (2003), Collier (2000), and Alesina (2003) all fall into this category.

Finally, we look at why this cultural isolation may be permanent. Following one of the insights of our simple theoretical framework, we investigate the correlation between geographic and cultural isolation. We find systematic differences in land settlement selection of migrants leaving the rainforest. North-south migrants selected land that was more similar to the rainforest, and this preference pulled them away from more heavily populated regions with a diversity of neighbours. They therefore settled in regions that were more geographically isolated which explains the persistence of the cultural isolation. So the costs to information acquisition are endogenous for potentially two reasons. The first is cultural isolation might create barriers to adoption, and result from a failure of information to fully diffuse. Second, the evidence supports the idea that geographic isolation responds to poor information flows as well. We view the cultural and geographic isolation as part of the same underlying mechanism, reinforcing each other. Because of this we are unable to separately identify the importance these two effects, but conclude that endogenous isolation, in general, generates higher information acquisition costs of new information.

Identifying the isolation mechanism, even without separating between the respective importance of geography and culture, requires us to overcome several identification challenges. One concern is that some unobserved event or set of events changed societal characteristics, and can explain differences in crop choices. One possibility is that migrants travelling through the rainforest interacted with different types of natives. It's unlikely that this would impact crop choices as both groups of Bantu migrants introduced settled agriculture to the areas they settled - there was no settled agriculture south of the Sahel prior to the arrival of the Bantu.

Regardless, we use the Altonji et al. (2005) test for assessing the plausibility of confounding unobservables to address this concern. The test examines the sensitivity

of results to different controls to measure how much unobservables would have to impact estimates relative to observables to explain away the result. This test is powerful when the ability to observe relevant factors is high. Because we have such rich data on land characteristics, which should account for most of the productivity differences, the test is quite powerful in our case. Results suggest that unobservable factors would have to be, as a lower bound, equally important as all land characteristics are for crop production. As an upper bound, unobservables would have to be 20 times more important. It seems unlikely that any factor would have a larger influence on crop production than land characteristics, so we interpret this as strong evidence that the relationship is not driven by unobservables.

Another potential concern is that tastes are endogenous. Tastes have been shown to impact production decisions in a developing economy context (Atkin (2013)), and it is possible that multigenerational migration had a lasting impact on tastes. Here the New World crops become important, since tastes had not been acquired for any of these crops. If dry crops were less produced because a taste for wet crops developed we should either see the same pattern on the New World crops, or we should see that none of the New World crops are less produced for north-south migrants.

The remainder of the paper proceeds as follows. In the next section we outline a very simple model intended to make the mechanisms discussed in the empirical section more concrete. In section 3 we review the history of Bantu migration. Section 4 describes the data while section 5 outlines the empirical strategies used, and the main results. Section 6 concludes.

2.2 Conceptual Framework

This section is intended to make mechanisms concrete by outlining a simple model which formalizes Diamond's insight. For a more formal treatment, see the appendix.

The framework is not meant to isolate these hypothesized mechanism from others that may produce similar predictions. Instead the empirical sections attempt to distinguish between potentially confounding mechanisms. Instead the goal here is to establish 3 conceptual points:

1. The availability of information to societies very far south may depend on its benefit to societies that are closer to the innovation.

2. If we could make information available to those it wasn't previously available to, we might see an immediate catch-up in knowledge. This is true when the cost of adoption is exogenous.

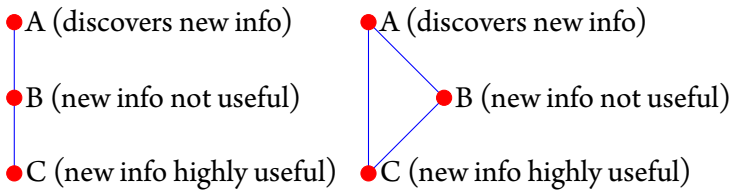
3. If the cost of adoption is endogenous, permanently low adoption becomes possible under some conditions. In this case, culture drifts apart as the incentive to communicate decreases.

2.2.1 Intuition

One key insight generating Diamond's axis orientation prediction was that diffusion between societies could be represented by a line network. While it's clearly not literally true that each society has only 2 neighbours from whom they can acquire information, it can be thought of that way because agricultural conditions are so highly correlated within latitudes that societies at each latitude behave the same. The implications for diffusion are drastic. If any one node along the line fails to 'pass the baton', diffusion ends. This does not occur in other network formations.

For example, consider the diffusion of a single piece of information in a line network of three societies (A, B, C). The information can either be useful to a society or not.

Figure 2.2.1: Network Effects



(a) Line Network (b) Complete Network

Suppose society A discovers the information and C would greatly benefit from the information (figure 1(a)). For C to acquire the information, they need to discover it from B, but B does not find the information useful. If B doesn't use the information, C will never discover it, and won't be able to apply it. Contrast this to a complete network in figure 1(b) where it doesn't matter whether B finds the new information beneficial, C can acquire it directly from A.

The implications for diffusion are clear. This highlights one important difference between society-society diffusion as compared to within-society diffusion. While within-society diffusion is arguably better captured by figure 1(b), Diamond (indirectly) argued that between-society diffusion was better captured by figure 1(a).

The key constraint in this set-up is the availability of information. It is straightforward to see how an intervention making the innovation available to society C would result in immediate adoption and would resolve the inefficiency. However, it is possible that the experiencing low information availability could influence the costs of adoption. In this case it is not clear that an information based intervention would immediately result in full adoption.

One example of that is the case where societies decide on whether or not to maintain communicative ties with other societies. The benefits of doing so are that they may observe some new agricultural technique that could be adopted and increase efficiency on farmland at home. The costs are that this requires occasional

visits over potentially large geographic distances, meaning time spent away from own crops, and as a result reduced agricultural profits. However, communication influences adoption costs by keeping cultural distance low. If a society decides not to maintain communication with others cultural drift occurs (e.g. language similarity), increasing the difficulty of understanding how new innovations work, and thus increasing the cost to adopt.

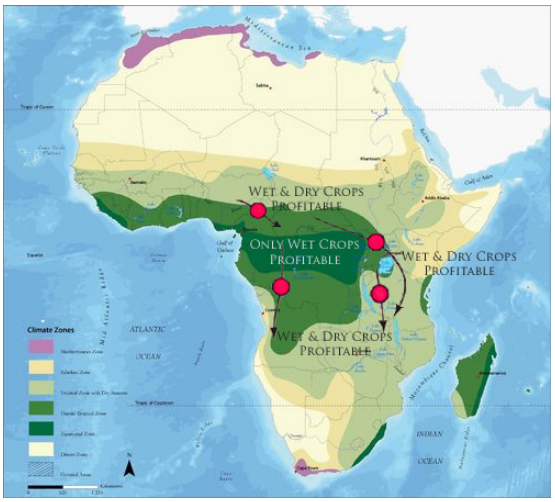
When societies live on very different types of land, as they do along a north-south axis, each visit to a neighbouring society is less likely to result in the discovery of an applicable profitable agricultural technique, so the benefit of visiting is low. A lowered benefit to visiting causes the society to visit less, increasing cultural drift. This further increases the cost of communication, and the cost of visiting in the future. If the benefit to maintaining communication with other societies is low enough, it is possible that the cultural drift could be so great that a discovered innovation that would have otherwise been adopted from a neighbour is never adopted.

2.3 Historical Background

Interested in the role of culture for information diffusion, we try to find a natural experiment that can distinguish between the main mechanisms. Ideally we would have a treatment and a control group that started out the same with some randomly assigned to travel along a north-south axis while the others go along an east-west axis. One society comes close to this: the Bantu.

The Bantu were a tribe that initially settled west Africa, on the Nigeria/Cameroon border. Population was stagnant until about the start of the common era (Guthrie (1948)). This was a period in African history that was experiencing a transition. It was the start of the iron era, and there were a number of technological advances being made in neighbouring regions, especially by the Nilo-Saharans to the north, in the

Figure 2.3.1: Migration routes during the settlement of Africa



The map shows the two main branches of migration. The branch that goes directly south migrates through the rainforest, while the branch that goes east then south avoids the rainforest. Both migration routes end up in the southern region of Africa which is the study region for the analysis in the paper.

Sahel, which diffused south to the Bantu (Oliver (1966)).

These technological advances caused large population boosts, and eventually migration. Prior to the introduction of iron to the Bantu homeland, migration always took place to the east (figure **??**). The west and north were already heavily populated, so migration in either direction would have led to conflict and settlement on smaller plots of land. They couldn't migrate to the south, because to the south was the rainforest, and cutting through the thicker landscape of the rainforest wasn't yet feasible. Land was freely available to the east, at least at first, so for about 100 years that was the dominant direction of migration. The introduction of iron caused a flood of migration south as it allowed migrants to clear the thick rainforest brush. The rainforest featured drastically more precipitation so the agricultural yield was better than to the east (Vansina (1990)), and because nobody could clear land before the introduction of iron, land was in abundance.

Despite the relative abundance of land to the south, the substitution away from dry

crops would have initially influenced productivity, and thus population growth and migration speed. "The situation suggests first very slow rate of movement as people were learning about new aquatic habitats followed by a dash once they had achieved mastery of their new environments" (Murdock (1959)).

The technological advancement of iron therefore led to two distinct groups of Bantu migrants: those who started east and those that started south. The eastern migrants though, didn't strictly travel east; they ended up travelling around the rainforest. They went east until they reached the east coast, then travelled south down east-Africa. Notably though, the agro-climactic conditions to the east of the rainforest are similar to those just north of the rainforest, and certainly not as different as through the rainforest (figure **??**). Both groups eventually went south, and were reintroduced to each other in southern Africa, 800 years later.

To study the impact that the orientation of the migration axis had on information flows, we examine agricultural production and technologies used. There are a number of agricultural products that are very useful along the borders of the rainforest but are not able to be grown in the rainforest. The first of these are livestock. Animals were very difficult to keep in the rainforest because of the tsetse fly, but were well kept just outside of the rainforest (Klein Goldewijk et al. (2010)). Similarly dry-crops were not suitable for the rainforest, but were grown well just outside the rainforest. Dry crops included: sorghum/millet, cotton, barley, wheat, maize and soy (FAO). On the other hand, wet crops were grown in both the rainforest and just outside the rainforest, but were grown especially well in the rainforest. Wet crops were grown about equally well as dry crops in the moderate climate just outside the rainforest. Wet crops included: rice, pulses, oils, sunflower, groundnut, sugarcane (FAO).

The timing of the introduction of each crop is very important. Many of the crops listed above were introduced well after migration took place, during the slave trade.

These are new world crops that were successful in central and south America that were brought over on slave boats to be sold to Africans, who lived in similar climates. Maize, soy, sunflower, groundnut and sugarcane all fall in this category. Another set of crops are traditional to Africa - in that they were either native to Africa or were discovered in the fertile crescent, and were adopted by Africans well before contact with the west. Included in this category are sorghum and millet, cotton, barley, wheat, rice, pulses and oils.

Traditional crops and use of livestock are both more appropriate to study if we're looking solely at the flow of information from the Bantu homeland to the final settlement locations, but the slave trade crops can be very useful in examining endogenous barriers to adoption. If information flows were compromised along the north-south axis then it is likely that the knowledge of how to produce dry-traditional crops did not survive the (multi-generational) journey through the rainforest. The eastern migrants, able to produce both wet and dry crops continuously, are likely to have kept their knowledge of both classes of crops.

The new world crops on the other hand only inform adoption of new crops after settlement. One of the hypotheses advanced was that when information flows are compromised, cultural drift becomes more likely, impairing future acquisition of information. This hypothesis can be tested by looking at the acquisition of the New World crops. If cultural/language barriers are endogenous to information flows, then the southern migrating Bantu would have adopted less of *all* new world crops.

2.4 Data

Data to test the three main predictions outlined in the conceptual framework, we need data from several sources. We use GIS data on historical settlements, and combine this with ethnicity maps and language tree data to identify migration patterns. This

data is combined with data on agricultural practices to measure information flows.

2.4.1 Historic Population Density Data

All tests involving historical population patterns use a 1° by 1° cell because of the higher uncertainty with the historical data. Two datasets are used independently to determine historic population density, McEvedy (1978) and Klein Goldewijk et al. (2010). The McEvedy (1978) data was geocoded for each period from 1C.E. to 1500C.E. (figure 2.7.5). It provides population data for various regions of Africa. To get the data at the 1° by 1° cell level, a technique designed[8] specifically to increase the precision of population data, by Moon and Farmer (2001), was used to smooth the data. This technique smoothes the data in a two step process, first determining the most likely regions for population using land quality, and second smoothing the data to the level desired. The aggregate population count within the initial regions, as defined by McEvedy (1978) is preserved under this method, but the end result is that the data is disaggregated using a well known, and generally accepted methodology.

The McEvedy (1978) data offers the advantages of having been constructed prior to Diamond's hypothesis being published, and being the most familiar and popular population dataset used in economic research. However, the drawback is that the dataset must be processed as described above to achieve the required resolution. An alternate dataset is available which can be used without any processing, but which was published after the Diamond hypothesis was published. The concern is that Diamond's theory may have informed historic population estimates in the generation of the data. However, the hope is if consistent estimates are obtained between the two datasets, both the data processing issue and the publication date issue can be ruled out as possible alternate explanations.

[8] called pychnophylactic interpolation

The Klein Goldewijk, Beusen, and Janssen data comes at a 5' by 5' resolution, and is aggregated to the 1° by 1° level. This data relies on historical sources and anthropological findings, along with probability models based on land quality and proximity to water to make historic estimates of population density and land use.

In addition to the population data, land use data from Klein Goldewijk, Beusen, and Janssen is also used. This data provides, for each cell, the km² of each cell that is devoted to either crop production or pastoral activities. This land use data also comes in a 5' by 5' resolution, and is aggregated to the 0.5° by 0.5° level.

2.4.2 Language Tree Data

Assigning migration routes to cells was accomplished using the ethnolinguistic map of Murdock (1959). For each group on the map, the associated language was identified and matched to the Ethnologue (Lewis (2009)). Each group is traced back along the Ethnologue language trees, which at one level provides an east-south language split analogous to the migration split. This split is used to assign migration routes.

An example is presented in figure **??** to illustrate the technique. In the example, the Kissama society is located on the Murdock map. Each cell within the borders determined by this map are assigned to one of either a 'not Bantu' or 'rainforest Bantu' or 'non-rainforest Bantu' value. These values are determined using the language trees from the Ethnologue. The language associated with the Kissama is identified and located on the Ethnologue tree. If the language is traced back to a Bantu root, it is assigned either a 'rainforest Bantu' or 'non-rainforest Bantu' value. The language tree differentiates between these values at the second level from the root of the tree. In this case, the Kissama would be assigned to the southern route.

The language tree data is also used to derive a measure of cultural isolation.The measure considers linguistic similarities as a proxy for cultural connectedness. Using

language trees to measure cultural differences is an idea first implemented by Desmet et al. (2011), and a related measure is adopted here.

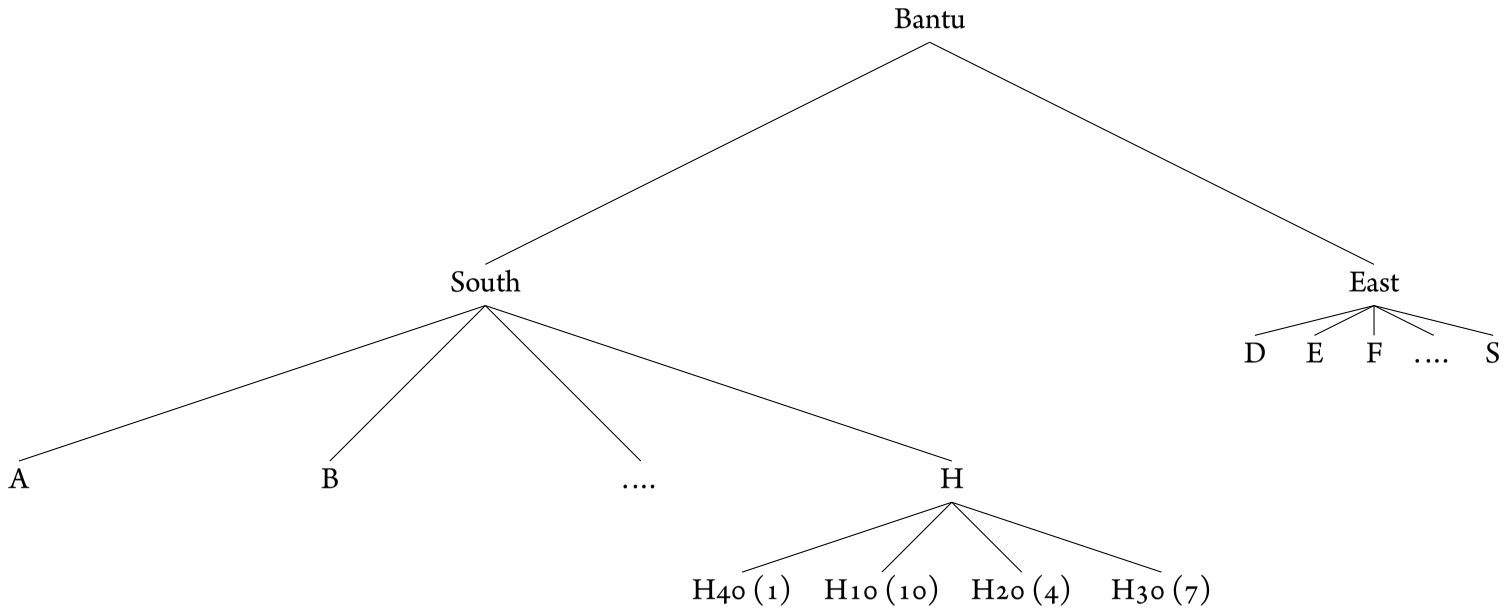
A fixed point is taken on the language tree, and the number of connections one group can make using this fixed point as a root is measured. The choice of the level to fix as the root level was made by taking the coarsest possible level at which some tribes would still be completely isolated (e.g. H40 in figure 2.4.1). Going finer than this would bias the measure by making very isolated tribes appear less isolated than they are, and going coarser than this would reduce variance in the measure. Many connections implies a low level of isolation. Figure 2.4.1 shows an example for sub-group H. Denoted in brackets are the number of tribes that end if that branch of the tree is followed. There are 10 tribes in the data with H.10 as a root, so a connectedness score of 10 is assigned.

The idea is that fixing cultural distance by fixing a point on the language tree allows for an interpretation of the measure where societies have a high or low number of connections for some fixed level of cultural distance.

2.4.3 Crop Suitability Data

FAO Crop suitability data was acquired to control for selection on land characteristics (figure 2.7.2). The data provides a suitability measure ranging from 1-8 for each major crop of Africa. This data comes, again, at the 0.5° by 0.5° level. In each cross-section analysis (where cell fixed effects are not possible) suitability for each crop is included as a fixed effect. This controls for the suitability of each crop considered, as well as its substitutes and compliments. If each crop is being produced efficiently by both groups, there should be no differences in production, controlling for suitability and land quality.

Figure 2.4.1: Bantu Language Tree. The numbers in brackets denote the number of tribes with that point as their root.



This figure shows how language data is used to develop a measure of cultural connectedness. The numbers in brackets represent the number of societies that use that point as a root. This fixed point on the tree is taken and the number of connections each society can make going through that fixed point is measured. Societies that can make more connections using a singe fixed point are interpreted as being more culturally connected. In the example all societies using H10 as their fixed point receive a cultural connectedness score of 10 as there are 10 societies using that root.

2.4.4 Contemporary Data on Crop Productivity

Data on contemporary production of the major crops grown in Africa is used to show gaps in productivity (Leff et al. (2004)). In this dataset, the continent is divided into 0.5° by 0.5° cells and provides, for each cell and each major crop, the percentage of the cell devoted to the production of that crop.

This data also includes a measure of land quality, which is used as a control in each relevant specification. The land quality data also comes at the 0.5° by 0.5° level. These 0.5° by 0.5° cells are used as the unit of observation for all tests involving specific crop estimates.

2.5 Empirical Results

We aim to test the three main predictions of the conceptual framework. For each of the three predictions, we show evidence using two different empirical designs. This improves identification, as different designs use different identifying assumptions, and it also helps to alleviate concerns over measurement error, which should be taken very seriously given that much of the historical data is imputed and smoothed by the data creators, to best approximate historical conditions.

First, we establish that information historically did not diffuse along the north-south axis as efficiently as it did along the east-west axis. This confirms Diamond's key hypothesis that the availability of information depends on its benefit to societies close to the innovation.

Second, we show that there was not an immediate catch-up in information when the southern societies neighbours all of a sudden had access to beneficial information. In fact, we show that low adoption appears to be permanent. This establishes one of the main contributions of the paper, which is to demonstrate that cultural barriers are

endogenously determined by information diffusion.

Finally, we offer evidence consistent with the hypothesis that the low permanent adoption is related to cultural isolation. We show (i) that southern migrants had a lower preference for integration, and (ii) that societal characteristics of north-south migrating societies are different with respect to isolation based measures, but not other measures.

2.5.1 Information Diffusion and Axis Orientation

We begin by demonstrating that axis-orientation matters for information flows. This result follows from Diamond's key insight that high diffusion information between societies depends on the usefulness of the information to all societies, not only the adopting societies.

We show this two different ways. First, using two different sources of population data, we show that migration patterns are consistent with lower transmission of information along the north-south axis. Second, we show that information on keeping livestock did not survive along the north-south route as well as it did along the east-west route. This is consistent with the axis-orientation hypothesis, as livestock is not profitable in the rainforest due to the presence of the tsetse fly.

Migration Speed Patterns

We begin by looking at migration speed patterns as migration speed is related to agricultural productivity. In a Malthusian environment productivity generates higher births, more population pressure and faster rates of migration. We therefore interpret differences in migration speed at the migration frontier as differences in agricultural productivity.

This relates to information diffusion in two ways. First an initial drop in migration

speed as migrants entered the rainforest indicates that the same agricultural techniques that were previously useful, are no longer generating the same levels of success. This establishes the relevancy of the exercise in testing the axis-orientation hypothesis. We expect migration speed to fall as migrants adapt to the new agricultural techniques required for rainforest agriculture.

Second, we can observe changes in migration speed as migrants exit the rainforest. South of the rainforest, the same dry crops that were produced just north of the rainforest in the Bantu homeland, once again become suitable for production. If the information necessary to produce these crops well survived the multigenerational migration through the rainforest, then there should be no reduction in migration speed leaving the rainforest, as migrants should be well prepared for the agricultural environment in southern Africa.

The specification used to test this hypothesis is:

$$Frontier_{ct} = \beta_0 + \beta_1 SouthRoute_c \cdot Post_t + \beta_2 SouthRoute_c + \beta_3 Post_t + \Gamma_c + \varepsilon \quad (2.1)$$

c is a cell and t is a unit of time. *Post* refers to the second period of any two-period panel analyzed. So for example, we look for a decrease in migration speed upon entering the rainforest between year 200-400C.E., and construct a dataset of population by cell which includes year 200 and 400. *Post* refers to observations taking place at year 400 in this case.

The outcome *Frontier* measures whether a geographic cell belongs to the migration frontier, and if so, takes the distance of this cell from the Bantu homeland. The frontier is defined as any cell with hunter/gatherer density in the 'before' period, and settler level population density in the 'post' period. β_1 therefore measures the differential in migration speed in $km/200years$, with faster migration speeds.

Table 2.7.2 shows the speed of the migration frontier throughout time in km/200

years. The individual estimates are less informative than the pattern formed by the estimates, which is most easily seen in figure 2.5.1. There must be drop in migration speed both entering and exiting the rainforest for the results to be consistent with the hypothesis that axis orientation is important for information flow.

The top and bottom panels of figure 2.5.1 use different datasets but also produce very similar patterns. The Klein Goldewijk, Beusen, and Janssen data shows the migration into the rainforest occurring about 100 years earlier than the McEvedy and Jones data, in both cases there is a drop in migration speed within the 1C.E.-300C.E. time range that iron working is known to have arrived in the Bantu homeland. This implies that there was an adaptation period where dry-crops were phased out, as described in the history literature. In both cases there is complete convergence until 1000A.D. This is also important as it rules out the possibility that migration was slower in the rainforest simply because it was inherently more difficult to navigate.

The panels on the right show the change in migration speeds exiting the rainforest for the north-south migrants relative to the east-west migrants. There is a second drop in migration speed at the time the migration frontier is known to have exited the rainforest, although convergence occurs much faster in the Klein, Goldewijk, Beusen and Janssen data. The decline in speed upon exiting the rainforest is significant in both datasets.

This general trend can also be seen in table 2.7.2. Migration speeds dropped by between 1-4km per year upon entering the rainforest (column(2)), small but significant effects. Upon exiting the rainforest, speeds dropped again, but by less. The speed of the frontier declined by roughly 1/4 to 1/2 a km per year exiting the rainforest (column (6)-(7)). This is consistent with Diamond's axis orientation theory, suggesting that information on how to produce dry-crops was better retained along the east-west axis than along the north-south axis.

Historical Land Use: Pasture Land

Of course, the migration speed patterns represent a very indirect measure of information and likely contain considerable measurement error. So we test the same hypothesis using a different measure: land devoted to livestock. Livestock is not kept in the rainforest with the same frequency as just outside the rainforest because of the tsetse fly. It has the advantage of more directly reflecting information through actual agricultural practices. We expect that upon exiting the rainforest there is still less land devoted to livestock, if the knowledge of how to keep livestock was not maintained during rainforest migration.

Land devoted to livestock is available every century starting in 1500C.E., so we can test whether livestock was less used by the north-south migrants than the east-west ones at the time settlement ended. Additionally, we can begin to examine whether there was a catch-up in knowledge once east-west migrants and north-south migrants were neighbours again. After settlement ended, information on how to keep livestock was available from neighbours of north-south migrants, and under constant and exogenous cost of adoption we would expect immediate catch-up. Under endogenous barriers to adoption based on cultural factors, immediate catch-up is not necessary.

To test these hypotheses, we rely on the following empirical specification:

$$\begin{aligned} Livestock_{ij} = & \beta_0 + \beta_1 Bantu \cdot South_{ij} + \beta_2 Bantu_{ij} + \beta_3 LandQuality_{ij} \\ & + \Gamma SuitabilityFE + \tau_j + \theta f(Coordinates) + \varepsilon_{ij} \end{aligned} \tag{2.2}$$

Subscript j denotes regions and i denotes cells. β_1 is the variable of interest, providing an estimate of historical livestock production for the rainforest Bantu relative to the non-rainforest Bantu. If knowledge of livestock was less successfully transmitted along the north-south axis, then $\beta_1 < 0$ at least for the year 1500C.E. If

the rainforest migrants failed to re-acquire the information about keeping livestock, even when it was available from their neighbours, we should expect $\beta_1 < 0$ for the years 1600C.E., 1700C.E. and 1800C.E. as well.

Table 2.7.5 shows estimates of the adoption of livestock over time by the southern migrating Bantu. Less livestock is used by southern Bantu, consistent with previous estimates using contemporary data. The effect is remarkably stable. In fact the estimates slightly decrease over time - though there is no statistically significant difference in any of the 4 estimates. The estimate in column (1) of table 2.7.5 is consistent with Diamond's conceptual contribution, while the stability of the estimates in columns (2)-(4) suggests *permanently* low information acquisition. Permanently low acquisition is possible when language and cultural barriers are endogenous to information flows, but it requires a combination of few neighbours, a high heterogeneity in historical environment and difficult assimilation.

One concern with this result is that the livestock data relies on modelling by geographers, and based on anthropological findings. It is possible therefore, that very few anthropological findings dating to between the 16th and 19th centuries is interpreted by modellers as little progress. Because of this, the estimate in column (1) which refers to livestock in 1500C.E. is taken more seriously than the dynamics. However the implications of the stability of the estimates is not ignored. We investigate the possibility of permanently low adoption further in the sext section.

2.5.2 Permanence of Low Adoption

We now turn to the possibility that information acquisition was permanently impaired by the low information transmission associated with rainforest migration. Again, two different approaches are taken.

First we look at the current production of crops using GIS satellite data of southern

Africa. We look at differences between dry and wet crops that are traditional to Africa to get test whether any lost information of dry crop production was ever re-acquired. We also examine the crops introduced through the slave trade. We expect different adoption patterns between these crop types to confirm the permanently low adoption hypothesis, and the two crop types taken together allow us to rule out competing explanations.

Next we examine the introduction of Maize much more closely. The introduction of Maize was a significant technological shock to southern Africa as it is now one of the most frequently grown crops in the region. We look at differential increases in land devoted to agriculture in regions settled by migrants along each route. If the availability of information about Maize did not increase the fraction of land devoted to agriculture, even controlling for the suitability of maize and all of its substitutes and compliments, then this information was unlikely to have been acquired. In this case the implication is that there is a deficiency in the general acquisition of new information associated with a north-south axis. This prediction follows from costs to acquiring information being endogenous to the efficiency of information diffusion, but not otherwise.

Current Production of Crops

We examine whether the information about the seemingly lost knowledge of dry crops among north-south migrants ever caught up to that of their neighbours, the east-west migrants. The issue is theoretically ambiguous, but a failure to catch-up is not possible under exogenous costs of information acquisition. To separate different possible mechanisms we investigate three crop types.

The three crop types are: (1) dry-traditional crops which can not be produced in the rainforest, and would have had to be readopted by rainforest migrants in southern

Africa. (2) Wet-traditional crops which were produced in the rainforest and would not have had to be readopted by rainforest migrants. This falsification test helps to rule out alternate explanations like selection on ability. (3) New world crops, which were introduced after the Bantu settlement, and which would have had to have been adopted by all Bantu migrants regardless of migration route.

This third group is helpful in ruling out alternate explanations like endogenously changing tastes, since tastes had not been acquired for any of the new crops by either group. It also helps to rule out selection into migration route based on wet-crop comparative advantage - since we expect differences in the production of both the wet and dry new world crops, not just the dry crops.

Groups are compared south of the rainforest[9] in a difference-in differences specification.

$$\begin{aligned} log(CropProduction)_{ij} =& \beta_0 + \beta_1 Bantu \cdot South_{ij} + \beta_2 Bantu_{ij} + \beta_3 LandQuality_{ij} \\ &+ \Gamma SuitabilityFE + \tau_j + \theta f(Coordinates) + \varepsilon_{ij} \end{aligned} \tag{2.3}$$

Subscript j denotes regions and i denotes cells. β_1 is the variable of interest, providing an estimate of the relative production of each crop by those whose ancestors migrated through the rainforest to those whose ancestors migrated around it. If knowledge of dry-traditional crops failed to be re-adopted by the rainforest migrants, then $\beta_1 < 0$ for all dry crops, but none of the wet ones. We also consider New World Crops. For these, all crops, wet or dry, are expected to produce an estimate of $\beta_1 < 0$. This would indicate that migration through the rainforest caused a change in the way societies learn about cropping techniques.

[9] below 9°S

β_2 differentiates between Bantu of either type from the other groups in the region. β_3 estimates the impact of land quality. This is important because the measure of agricultural output is the percentage of a cell devoted to cropping any particular crop. It shouldn't be the case that lower productivity of some crops is due to less of all crops being produced in the cell. The land quality controls for this general level of suitability for agriculture. Γ estimates a vector of suitability fixed effects. This is different from the more general land quality measure because it provides the suitability for each crop specifically rather than the suitability for general agricultural output. τ is a vector estimating the regional fixed effects included in the specification which ensure that contextual factors like institutions or infrastructure[10] are the same between comparison groups. It also further ensures that comparisons are made between societies on similar land. θ controls for the effect of latitude and longitude.

Table 2.7.4 presents the relationship between migration and cropping patterns split by crop type. In panels A and B crops traditional to the Bantu homeland are considered. Panel C and D considers New World crops introduced through the slave trade.

The results between panels A, C, and D are not substantially different. In Panel A, the largest effect can be seen in column (1) which shows that the combined effect of knowledge loss and inefficient re-adoption accounts for a 35% gap in current sorghum production. In panel C, the largest effect is on maize, which is about 32% less produced by those whose ancestors migrated through the rainforest. Considering the other crops, table 2.7.4 shows that every crop that had to be adopted at some point throughout southern Bantu history is less produced for descendants of southern relative to eastern migrants. The effect ranges from less than 1% (wheat) to 35% (sorghum).

[10] transport costs, etc.

The placebo wet-traditional crops in panel B are also important as they can rule out some alternate explanations. For example, it seems unlikely that south migrating farmers have smaller plots, or are of lower general agricultural ability based on the fact that wet crop farmers are equally productive between migration routes. It also demonstrates that the results aren't driven by imperfect suitability controls. All estimates are positive, but not significant. Magnitudes are much smaller than the 35% gap estimated for some other crops, but still, differences in rice and oil palm are slightly less than 5%. This isn't surprising, as some substitution should be expected. While north-south societies produce less of *every* crop that required adoption the do not produce less of *any* crop not requiring adoption.

Historical Land Use: The Impact of Maize

One of the ways that we demonstrate the general nature of the consequences of the low information diffusion along the north-south axis is to look at the effect on the adoption of information which was not impacted by the north-south axis. This was the spirit of the investigation of New World crops above, and here we look in more detail at one of those crops, using a different source of data.

We analyze whether there was a relative change in the allocation of land to crop production around the time of the introduction of maize to southern Africa. Maize increased the profitability of crop production in general, and any societies exposed to the new crop would have allocated more resources to agriculture. If east-west societies were better able to adopt new information *in general*, this would have led to a higher increase in allocation to crop land for those who migrated around the rainforest than for those who migrated through the rainforest.

The history literature places the introduction of maize to southern Africa[11], the

[11]Evidence exists on the time it was introduced to the Cape regions

most widely produced of the new world crops, at sometime between the mid to late 16th century and the early to mid 17th century. These two centuries were used as the treatment periods while the next two centuries were used as a placebo. No major shocks to agricultural productivity occurred during these centuries, so there should be no reason to see a relative difference in the growth or contraction of land allocated to crops.

The hypothesis is tested with the following model:

$$LandUse_{it} = \beta_0 + \beta_1 BantuSouth \cdot Post + \beta_2 Bantu_south + \beta_3 Bantu + \gamma_t + \varepsilon_{it} \quad (2.4)$$

If the descendants of eastern migrating Bantu were more likely to adopt New World crops, the expectation should be that $\beta_1 < 0$ for the 16th and 17th centuries, but not for other centuries. If southern migrating Bantu were more likely to adopt New World crops, $\beta_1 > 0$ and if they were equally likely, $\beta_1 = 0$.

Table 2.7.4 shows that south migrating Bantu increased their crop use by 24% less than as eastern migrating Bantu after the introduction of maize (columns (1) and (2)). The estimate is similar to contemporary estimates which are between 5-30% (Table 2.7.4). Historically, knowledge acquisition among the descendants of southern migrating Bantu failed to adopt new technologies.

2.5.3 Cultural Isolation, Geographic Isolation and Persistence

We've seen that a north-south axis seems to have led to a failure of the full diffusion of information, and that this effect has had long lasting implications for the acquisition of all types of information. It has been argued that the mechanism driving the generality of the effect is the increase in isolation, endogenously arising from low incentive to maintain relationships with other societies.

We now present evidence consistent with this argument. We show first that

language barriers between societies are larger for those whose ancestors migrated through the rainforest. The conceptual framework predicts that an increase in cultural isolation should be correlated with an increase in geographic isolation as well (ν in the model). We therefore test the evolution of both cultural and geographic isolation resulting from poor information diffusion. We find evidence which supports the theoretical prediction that geographical and cultural isolation are correlated.

The evidence suggesting endogenous geographic isolation provides an explanation for why the linguistic barriers have not been eroded over time. On the other hand though, because both geographic and cultural isolation seem endogenous to information diffusion, it means that neither can be identified separately from the other. We conclude that isolation, in general, is responsible for the persistence of the impaired ability of rainforest migrant descendants to adopt new information.

Axis Orientation and Linguistic Isolation

First we provide some evidence that language barriers are greater for societies with a history of rainforest migration. We use the same model as before, now to test the effect of axis orientation on our measure of linguistic isolation. We interpret a society without any languages that are similar to it as one that has experienced substantial cultural drift, and one with a high cost of acquiring information from other societies. In this way, our measure of linguistic isolation represents the variable c from the conceptual framework. Recall that the endogeneity of c was necessary to generate the permanence of the axis orientation effect.

As a direct test of whether c is endogenous to information flows and axis

orientation, we use the following specification:

$$\begin{aligned} LinguisticIsolation_{ij} = &\beta_0 + \beta_1 Bantu \cdot South_{ij} + \beta_2 Bantu_{ij} + \beta_3 LandQuality_{ij} \\ &+ \Gamma SuitabilityFE + \tau_j + \theta f(Coordinates) + \varepsilon_{ij} \end{aligned} \tag{2.5}$$

The model is the same as in previous tables, with β_1 representing the differential effect of axis orientation on language barriers. The estimate can be interpreted as the effect of axis orientation on the number of other societies with whom a linguistic similarity was maintained.

The results are found in table 2.7.6. We find that on average a north-south axis orientation results in maintaining communication with 3 fewer societies. The mean number of connections is 6.45 and the standard deviation is 3.41. So a North-South axis represents nearly half of a standard deviation in linguistic isolation. This is an economically meaningful effect, and one that is consistent with the large estimates on agricultural productivity.

Axis Orientation and Geographic Isolation

One remaining question is why did language barriers develop when information flows decreased, but did not erode after settlement in the south, when information became available again? The conceptual framework suggests one possible answer, the endogeneity of geographic isolation. In the case of the Bantu, who were constantly choosing new settlements, it is reasonable to think that their selection of land to settle was influenced by both their their cultural isolation and their expected future benefit of new information. Reducing geographic isolation becomes less attractive because cultural isolation is high and there is little incentive to invest in reducing cultural isolation because geographic isolation is high. Societies are stuck in an isolated

equilibrium which reduces the acquisition of new information.

To test this we look at settlement locations chosen by southern and eastern migrants in southern Africa. We expect that southern migrants will be more likely to settle on land that is similar to their what they know how to do, so we expect them to settle on land more similar to the rainforest. On the other hand, this land is not particularly valuable to the eastern migrants, so if these selection mechanisms are taking place, we expect that the distance to dry-crop information is increased for southern migrants relative to what it would otherwise would be.

To test this hypothesis, we develop an index of similarity of a piece of land to the rainforest. The index is:

$$Index_i = 64 - \sum_{i}^{8} (suit_{ic} - \bar{suit}_{cr}) \tag{2.6}$$

Where ic represents suitability of crop c in cell i, and cr denotes the suitability of crop c in a rainforest cell. The index takes the maximum value of the second term, 64, and subtracts from that the sum of the difference between the suitability of any crop in the cell of interest from the average suitability of that same crop in the rainforest. This provides a measure of the difference of any given cell to the average rainforest cell. To facilitate interpretation by avoiding the difficulties in interpreting estimates based on an arbitrarily scaled index, the variable included in regressions is an indicator taking a value of 1 when the index is above it median, and a value of 0 otherwise[12].

This index is included in a slightly different difference-in-differences specification

[12]The specification was tested as a binary and a continuous variable, and it makes little difference to the precision of the estimates.

to what has previously been used.

$$\begin{aligned} Pop_i = &\beta_0 + \beta_1 SouthRoute_i \cdot Index_i + \beta_2 BantuxSouth + \beta_3 Index_i \\ &+ \beta_3 Bantu_i + \beta_4 LandQuality_i + \Upsilon SuitabilityFE + \theta f(Coordinates) + \varepsilon_i \end{aligned} \tag{2.7}$$

$\beta_1 > 0$ is still the variable of interest. The model provides an estimate of the difference in population between those with and without a rainforest history, on land which is similar to the rainforest. Because those who migrated through the rainforest know more about land similar to the rainforest, they should be able to support a higher population when they settle on that type of land. Each of the other controls is the same as before. Land quality is a general suitability for agriculture variable, suitabilityFE gives a flexible control for crop specific suitability, and latitude and longitude coordinates are included flexibly.

Using population data and the Murdock map we can verify the prediction that sorting on land took place according to the agricultural knowledge at the time. If the southern migrating Bantu were more likely to settle on land similar to the rainforest, and had higher population growth on the land, it indicates that a knowledge gap existed historically, and this knowledge gap generated differences in geographic isolation.

Table 4.6.8 shows the results for both the Klein Goldewijk, Beusen, and Janssen data and the McEvedy and Jones data. Both datasets produce consistent estimates. Migrants with skills suited for rainforest crops were more likely to settle on this land than eastern migrants who had more diversity in production skills. Southern migrants were 9% more likely to settle on land that was similar to the rainforest. By the end of the Bantu settlement of southern Africa there were about 3.6 times more southern migrants in areas similar to the rainforest than eastern migrants.

The draw to this type of land seems to have reduced the number of eastern neighbours encountered by southern migrants, which may have prevented communication and assimilation to take place. As suggested by the conceptual framework, the reduced information diffusion along the north-south axis impacted several dimensions of isolation, which combined, reduced incentives to acquire new information. As a result, the descendants of southern migrating Bantu have not acquired new information, throughout history, with the same regularity as descendants of eastern migrating Bantu.

2.6 Robustness and Alternate Explanations

Tastes and Nutrition

One alternate explanation for different crops being produced by different societies may be based on tastes. Atkin (2013) provides evidence that Indian farmers consume fewer calories per rupee because of a cultural preference for certain foods. In the Bantu context, it could be that dry-traditional crops are inefficiently produced because of a cultural preference for wet-traditional crops rather than an inability to adopt new crops. This argument does not hold for the New World crops however. There could not have been a cultural preference for these crops since all societies were introduced to them at the same time.

Furthermore, both the eastern and southern migrants would be substituting away from a crop that they had developed tastes for. The substitutions in most cases were more costly for the non-rainforest migrants. As an example, consider the introduction of wheat, which is a New World crop that was less heavily by rainforest migrants. Wheat, nutritionally, is a substitute for sorghum and rice. However, sorghum has significantly more nutritional advantages over wheat than rice does, and would

therefore have been costlier for non-rainforest migrants to switch based on nutritional profile. The only advantage that rice has over sorghum is that protein from rice is of higher quality, although this benefit is eliminated once rice is cooked, and is fairly insignificant since each of rice, wheat and sorghum are very poor protein sources. Sorghum contains the highest levels of fat, and has far more calories per cup (650 sorghum; 250 rice; 600 wheat[13]).

Institutions

Another alternate explanation is that precolonial institutions may be related to geographic environment, and may have changed differentially for the two migration branches. However, institutions are also clearly related to culture, and we might expect more insular cultures to have more insular political institutions. Both of these hypotheses can be tested. Precolonial institution data is available from Murdock (1959). Data exists on institutional hierarchy at, and beyond, the local level, as well as on property rights. If cultural isolation changed institutions but nothing else did, we expect that political institutions beyond the local level will be smaller, but that property rights and hierarchy at the local level will be unchanged.

To test this the main specification used in equation (1) was applied to the 6 different outcomes: jurisdictional hierarchy beyond the local level; jurisdictional hierarchy at the local level, property rights (general), land rights, moveable asset rights and inheritance norms. Only the first of the 6 can be considered a part of the 'insular culture' mechanism. The rest act as a falsification test.

The first robustness check is on the cultural connectedness measure. It is a novel measure, so it should be shown that it is consistent with other measures that might typically used in its place. It is reasonable to expect cultural isolation to result in a

[13]nutritional information from wolframalpha.com accessed August 21, 2013

specific set of political institutions. Low levels of hierarchy will exist outside of the locality when migration is low, and interaction with other societies is limited. However, hierarchy within the locality should not be impacted by this cultural change. Migration through the rainforest will be associated with lowered hierarchy beyond the local level, but not at the local level if cultural isolation increased throughout migration.

At the same time other institutions should not have been altered by migration through the rainforest. The most concerning institutional difference which would plausibly impact productivity and knowledge adoption is property rights. Low land rights would limit the incentive to make investments in the productivity of the land, and this could include investment in knowledge acquisition.

The results are presented in table 2.7.8 and 2.7.9. Estimates show that jurisdictional hierarchies are less developed beyond the local level, but not at the local level in societies with rainforest histories. The falsification test results are presented in table 2.7.9. Each of the estimates is close to 0 and insignificant, meaning that property rights were unaffected by rainforest migration.

Occupation

One robustness check on the inefficient adoption hypothesis is that if agriculture is inefficient for one migration branch, it should be true that these people substitute away from the agricultural industry over time. This can be tested for a subset of countries using the DHS.

The DHS is used to determine the occupations of individuals of various ethnicities. In each case the most recent version was used, the dates of the surveys range from 1988 to 2006. Seven surveys from southern Africa (south of the rainforest) were combined: Malawi, Namibia, Zambia, Zimbabwe, Swaziland and Lesotho. South

Africa was not used because one of the required variables was missing. Unfortunately many of the controls previously available are not available here because the DHS is not always geocoded. Because of this the specification is extremely basic, and should be considered only as a suggestive, supporting piece of evidence to that above. A binary dependent variable for agricultural occupation is analyzed in the following specification.

$$AgrOccupation = \beta_0 + \beta_1 Bantu + \beta_2 Bantu \cdot South + \Gamma CountryFE + \varepsilon \qquad (2.8)$$

Here, β_2 is the variable of interest. The expectation is that if the previously identified barriers to adoption existed, there would be differential exit from the agricultural sector among southern migrants. The results can be found in table 2.7.10. The results indicate that Bantu speakers with a rainforest history are about 2% less likely to become agriculturalists than Bantu speakers whose ancestors went around the rainforest. This is consistent with the previous results, using a different dataset and suggests at least some of the effect seen previously is due to extensive margin differences.

Selection on Unobservables

The issue of conditional random allocation of migrants to southern migration and eastern migration is critical. The view of the history literature is that selection did not take place, but the issue has not been examined formally.

To do this we look at the Altonji et al. (2005) method of assessing selection on unobservables using selection on observables. The intuition behind the test is to measure how strong the selection on unobservables must be relative to the selection on observables in order to explain away the effects. This strategy relies on a comparison between a regression run with potentially confounding factors controlled

for, and one without.

Let β_c denote the estimate with controls, and β_{nc} denote the estimate without controls. The Altonji ratio is $|\beta_c/(\beta_{nc} - \beta_c)|$. When selection on observables does not significantly impact the estimate, the denominator is small, increasing the ratio. When the estimate itself is large, the ratio is large, because the numerator is large. The smaller is the impact of observables on the estimate, the larger the impact of unobservables has to be to reduce the effect. The larger the estimate itself, the larger the pull of selection needs to be to reduce the effect to 0. The rule of thumb outlined in Nunn and Wantchekon (2012) is that any ratio above 1 is acceptable, as it indicates that selection on unobservables must be larger than selection on observables in order to explain the effect. Of course this depends on the explanatory power of the observables, but in our case, given our abundance of soil and climactic data, this seems reasonable.

Table 2.7.11 shows the ratios of each of the main estimates. The 'full' specification is the same regression as in table 2.7.4 while the 'restricted' specification drops the controls for land quality, index of similarity to the rainforest, and all of the FAO crop specific suitability fixed effects. Only the variable of interest (Bantu x South), the Bantu term and the latitude and longitude controls remain[14]. For every estimate in which there was a precise result in the full specification, the Altonji ratio is well above the rule of thumb number of one, indicating that there is little concern that selection on unobservables is driving the result.

Measurement Error and Alternative Datasets

The main evidence uses the best available data, but in many cases the best available data is still questionable. The McEvedy and Jones data has been criticized on a

[14] removing the latitude and longitude controls makes little difference

number of dimensions. The production data is based on remote sensing images which are known to have a difficult time identifying some crops, especially when intercropped, and is almost certainly subject to some measurement error. While in each case, classical measurement error would work against the findings, not with them, it is still prudent to test the robustness of the findings with other sources of data. Because the robustness checks are themselves using even worse data (otherwise they would be presented as the main results) these results should not be considered in isolation, but solely as a check that the patterns in the main estimates are not due to measurement error.

The robustness check used the Afrobarometer data. The entire Afrobarometer was geocoded, and matched to an alternative source of crop production data, You et al. (2006). The unit of observation for this test was at the individual level. A settlement group was assigned to the observation based on the language spoken by the respondent in the Afrobarometer survey. All respondents in the same village were assigned to the same You et al. (2006) cell, so all analyses were clustered at the village level.

There are a number of advantages and disadvantages to this approach over the estimates used in the main results. First, information exists on individual farmers, so additional individual level controls became available. These included gender, education, exposure to the slave trade (taken from Nunn who also uses the Afrobarometer) and age. The ability to control for formal education was perhaps the main advantage. A number of other controls were added to this framework, to control for other potential explanations in the literature. Unfortunately data on every crop used in the main analysis was not available, so instead the main, or second to main, crop from each category was used as a representative. For dry-traditional crops, sorghum was used; rice was used for wet-traditional; maize was used to represent the

dry recently introduced crops, and groundnut was used for the wet-recent crops.

Table 2.7.12 shows the results of this robustness check. The traditional dry-crop, sorghum, is still significantly less produced by individuals whose ancestors migrated south. Each of the two recently introduced crops are significantly less produced as well, while the rice estimate is statistically insignificant and close to 0. This general pattern is very similar to the results found in the main analysis.

This robustness check also reassures that the main results are not driven by recent migration. It might have initially been worrisome that precolonial settlement data was being matched with current production data. The concern may have been that initial settlement was basically used as an exogenous proxy for current location, however no correlation between the two could be shown. Using survey data alleviates this concern, as it examines the current location of respondents rather than their historic settlement. There are pros and cons to this choice however. Current location is a choice variable of the individuals currently producing, so this leaves the estimates more open to selection criticisms. The initial settlement location is arguably a better measure to use as it is outside the control of current producers and so it suffers from fewer endogeneity issues.

2.7 Discussion and Conclusion

This paper investigates the key insight made by Jared Diamond with respect to information diffusion between societies, as well as some of the conceptual implications of the assumption. We find support for the idea that a north-south axis impairs information flows. We also find evidence that the low information acquisition is permanent, with evidence supporting the hypothesis that a north-south axis is associated with an increase in language barriers as well as an increase in geographic isolation, both of which make acquiring information from other societies more

difficult.

We make three main claims. First, a north-south dominant axis impairs information diffusion. Second, information acquisition does not immediately recover, even when information becomes available. Third, the reason for the long lasting effect is the endogeneity of isolation: when the incentives to acquire new information is reduced, societies become more isolated which increases the costs of acquiring new information in the future.

These findings are important for our understanding of how information flows between societies. In particular the endogeneity of isolation to the efficiency of information diffusion has direct policy implications. Under exogenous costs of acquiring information, we would conclude that the only barrier to increasing technology adoption between societies is the availability of information. However, these results suggest that this isn't the case. Societies with a history of unavailable information may need additional incentives to adopt new information to account for the larger language barriers they are likely to face. In other words, a history of inefficient information diffusion reduces the net benefit of new information.

We conclude that between-society information diffusion can have large impacts on productivity. But efforts to reduce both geographic and cultural isolation are likely more promising avenues for increasing technology adoption between some societies than policies aimed solely at increasing technological visibility or discovery.

Tables

Table 2.7.1: Summary Statistics

VARIABLES	Mean	St. Deviation	Minimum	Maximum
PANEL A: Population (people per cell)				
Population 0	2.76	5.62	0	127.90
Population 200	5.78	9.38	0	155.32
Population 400	8.85	14.79	0	170.46
Population 600	12.18	20.80	0	253.92
Population 800	16.18	27.32	0	337.28
Population 1000	19.55	33.58	0	421.35
Population 1100	24.47	40.60	0	510.48
Population 1200	28.75	47.61	0	600.14
Population 1300	33.26	54.66	0	689.73
Population 1400	38.31	61.70	0	779.15
Population 1500	43.39	68.80	0	868.63
PANEL B: Crop Production (percentage of cell devoted to production)				
Maize	2.08	4.17	0	41.4
Sorghum & Millet	.66	1.66	0	23.95
Cassava	.51	1.14	0	10.87
Groundnut	.21	.42	0	3.45
Rice	.20	.86	0	14.60
Cotton	.15	.35	0	3.80
Sunflowers	.15	.41	0	5.10
Pulses	.13	.30	0	4.10
Oil Palm	.089	.33	0	7.90
Soybean	.039	.10	0	.90
Sugarcane	.0092	.05	0	1.0

Population statistics are for Bantu regions only. Crop production statistics are for the southern region of Africa (south of -9 degrees latitude)

Table 2.7.2: Differences in the Speed of the Migration Frontier by Route (in km/200 years)

Panel A: Klein Goldewijk, Beusen, and Janssen Data

	1000b.c.-0	0-100	100-200	200-400	600-800	800-1000	1000-1200
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post x South	-16.845	-203.593**	117.872	-13.344	-32.742	-68.408	-73.044**
	(14.745)	(101.887)	(103.114)	(47.076)	(36.094)	(42.271)	(31.394)
R-squared	0.0185	0.0226	0.0047	0.0061	0.0120	0.0327	0.0638

Panel B: McEvedy and Jones Data

	0-200	200-400	400-600	600-800	800-1000	1000-1200	1200-1400
Post x South	-49.46	-873.7***	-68.47***	-2.11	-2.33	-37.64**	-42.50***
	(47.69)	(178.7)	(22.38)	(13.74)	(75.81)	(16.63)	(15.09)
R-squared	0.065	0.247	0.030	0.011	0.043	0.017	0.012
Observations	3926	3926	3926	3926	3926	3926	3926

Notes: Standard errors are clustered by region. Migration partition as described in Flight (1980) is used ({ABCHKLR:DEFGMNPS.}). Year dummies and cellFE are also included as controls.***p<0.01,**p<0.05,*p<0.1.

Table 2.7.3: Historical Land Use

Panel A: Historical Use of Land for Pasture

	(1) 1500C.E.	(2) 1600C.E.	(3) 1700C.E.	(4) 1800C.E.
Bantu x South	-0.666**	-0.697***	-0.720***	-0.711**
	(0.264)	(0.265)	(0.266)	(0.277)
Bantu	0.186	0.214	0.224	0.217
	(0.227)	(0.228)	(0.231)	(0.248)
Observations	3763	3763	3763	3763
R-squared	0.745	0.754	0.760	0.775

Notes: Standard errors are clustered by 2°x2° region. Migration partition as described in Flight (1980) is used ({ABCHKLR:DEFGMNPS.}). Dependent variable has been transformed using the inverse hyperbolic sine transformation. Controls include regionFE, crop suitabilityFE, land quality, coordinate polynomials, similarity to the rainforest, desert and distance to market. Pasture land units are km^2 per $.5^{\circ}$x$.5^{\circ}$ cell. ***p<0.01,**p<0.05,*p<0.1.

Table 2.7.4: Modern Crop Production by Migration Route

Panel A: Dry Crops Traditional to Africa

	log(Sorghum)	log(Cotton)	log(Barley)	log(Wheat)
South x Bantu	-0.348***	-0.111**	-0.0208**	-0.00239**
	(0.0770)	(0.0461)	(0.00948)	(0.000950)
Bantu	0.0564	0.0868***	0.0154	0.00171
	(0.0723)	(0.0308)	(0.0104)	(0.00107)
Observations	4524	4524	4524	4524
R-squared	0.547	0.613	0.474	0.473

Panel B: Wet Crops Traditional to Africa

	log(Rice)	log(Pulses)	log(Oil Palm)
South x Bantu	0.00161	0.0394	0.0309
	(0.0349)	(0.0358)	(0.0209)
Bantu	-0.000802	-0.0119	-0.00839
	(0.0166)	(0.0218)	(0.00899)
Observations	4524	4524	4524
R-squared	0.566	0.491	0.341

Panel C: Dry Crops Introduced During Slave Trade

	log(Maize)	log(Soy)
South x Bantu	-0.325***	-0.0358*
	(0.0953)	(0.0197)
Bantu	0.315***	0.0374***
	(0.0761)	(0.0135)
Observations	4524	4524
R-squared	0.780	0.524

Panel D: Wet Crops Introduced During Slave Trade

	log(Sunflower)	log(Groundnut)	log(Sugarcane)
South x Bantu	-0.114***	-0.0942*	-0.0536**
	(0.0362)	(0.0560)	(0.0220)
Bantu	0.102***	0.0927***	0.0417*
	(0.0333)	(0.0337)	(0.0218)
Observations	4524	4524	4524
R-squared	0.563	0.671	0.511

Notes: Standard errors are clustered by 2°x2° region. Migration partition as described in Flight (1980) is used ({ABCHKLR:DEFGMNPS.}). Dependent variable has been transformed using the inverse hyperbolic sine transformation. Controls include regionFE, crop suitabilityFE, land quality, coordinate polynomials, similarity to the rainforest, desert and distance to market.***p<0.01,**p<0.05,*p<0.1.

Table 2.7.5: Historical Land Use

	Use of Land for Crops before and after Maize			
	(1)	(2)	(3)	(4)
	1500-1600	1600-1700	1700-1800	1800-1900
Year x South	-0.243***	-0.270***	0.0940	-2.420
	(.0680)	(0.0806)	(0.332)	(1.839)
Year (post)	0.324***	0.382***	1.035***	7.768***
	(0.0632)	(0.0744)	(0.211)	(1.354)
Observations	10304	10304	10304	10304
R-squared	0.034	0.036	0.027	0.047

Notes: Standard errors are clustered by 2°x2° region. Migration partition as described in Flight (1980) is used ({ABCHKLR:DEFGMNPS.}). Dependent variable has been transformed using the inverse hyperbolic sine transformation. Controls include regionFE, crop suitabilityFE, land quality, coordinate polynomials, similarity to the rainforest, desert and distance to market. Pasture land units are km^2 per $.5^{\circ}$x$.5^{\circ}$ cell. ***p<0.01,**p<0.05,*p<0.1.

Table 2.7.6: Impact of Axis Orientation on Language Barriers

	Dependant Variable: Linguistic Similarity			
	(1)	(2)	(3)	(4)
Bantu x South	-3.519***	-3.543***	-3.067***	-2.875***
	(0.448)	(0.446)	(0.417)	(0.379)
Distance to Major Market	NO	YES	YES	YES
Land Quality	NO	YES	YES	YES
Latitude and Longitude	NO	NO	YES	YES
Suitability FE (all crops)	NO	NO	NO	YES
Observations	5076	5076	5076	5076
R-squared	0.305	0.378	0.394	0.438

Notes: Standard errors are clustered by 2°x2° region. Migration partition as described in Flight (1980) is used ({ABCHKLR:DEFGMNPS.}). Dependent variable has been transformed using the inverse hyperbolic sine transformation. Controls include regionFE, crop suitabilityFE, land quality, coordinate polynomials, similarity to the rainforest, desert and distance to market.***p<0.01,**p<0.05,*p<0.1.

Table 2.7.7: Sorting into Regions Similar to Rainforest

Panel A: Klein Goldewijk, Beusen, and Janssen Data

Dependent Variable: Population per cell

	1000 (1)	1100 (2)	1200 (3)	1300 (4)	1400 (5)	1500 (6)
Bantu South x Similarity	4011.1***	4132.9***	5127.4***	5102.1***	6466.6***	7194.6***
	(1274.1)	(1421.6)	(1681.2)	(1818.4)	(2183.8)	(2456.1)
Similarity Index	-687.61	-509.3	-918.2	-676.7	-1134.61	-330.5
	(591.6)	(654.1)	(756.8)	(829.23)	(966.5)	(1090.6)
R-squared	0.2280	0.2543	0.2667	0.2895	0.2934	0.2494

Panel B: McEvedy and Jones Data

Dependent Variable: Population per cell

	1000	1100	1200	1300	1400	1500
Bantu South x Similarity	196.1	351.6	474.5*	608.6*	776.0*	937.8**
	(171.7)	(226.1)	(278.3)	(330.7)	(392.8)	(453.4)
Similarity Index	167.9	181.0	185.2	191.0	202.5	212.4
	(108.9)	(140.2)	(172.2)	(204.8)	(237.8)	(271.1)
R-squared	0.126	0.138	0.156	0.170	0.175	0.181
Observations	935	935	935	935	935	935

Notes: Standard errors are clustered by region. Migration partition as described in Flight (1980) is used ({ABCHKLR:DEFGMNPS.}). Controls include language subgroup FE, land characteristics controls and coordinate polynomials.***p<0.01,**p<0.05,*p<0.1

Theoretical Framework

To formalize: let someone from society C earn some benefit i_c from the info, after adopting it at some cost c. Assume for now that the cost of adoption is the same for all. Their utility would be $U_c = i_c - c$ if they adopt, and 0 if they don't. Since here we assume that $i_c > c$ we can formalize the utility function for society C as:

$$U_c = \begin{cases} i_c - c, & \text{if } i_B > c \\ 0, & \text{otherwise} \end{cases} \tag{2.9}$$

2.7.1 Diffusion of information: two cases

The benefit of i to a society may therefore depend on the number of network nodes between the innovation the society. Let the number of nodes and the nodal distance from the innovation be x. So, the innovation occurs at $x = 0$ and any direct neighbours of the innovator have $x = 1$; neighbours of neighbours have $x = 2$, and so on.

Following Diamond, consider two possibilities:

1. Information is equally valuable across all nodes between the innovation and x $\forall x$. This is Diamond's east-west axis.

2. The benefit of information is quadratic in x. This is like a north-south axis. It's not that beneficial to people in the middle, but quite beneficial to those very close to and very far from the innovation.

2.7.2 Case 1: East-West

Suppose $i_x = i \, \forall x$. Diffusion of information is trivial. Everyone gets benefit i. Either everyone in the network acquires the information ($i \geq c$), or nobody does ($i < c$).

2.7.3 Case 2: North-South

Along the north south axis, we have a technology discovered in the north which becomes less useful near the equator, and which becomes more useful again south of the equator. We can describe the benefit of the information as a quadratic function, to see how far down the network a piece of information will get.

Let $i_x = (zx - y)^2$. The info will be adopted by all x for which $i_x \geq c$. In this equation z represents the difference in the environment between each node (e.g. vastness of land, or something similar), and y represents the nodal distance to the innovation from the median x (e.g. network size). Diffusion stops when some society $\bar{x}$ no longer finds adoption worthwhile. That is, $U_{\bar{x}} = 0$. All societies less than $\bar{x}$ adopt, where $\bar{x}$ is:

$$\begin{aligned} 0 &= (z\bar{x} - y)^2 - c \\ \bar{x} &= \frac{y \pm \sqrt{c}}{z} \\ \bar{x} &= \frac{y - \sqrt{c}}{z} \end{aligned} \tag{2.10}$$

The lower value is taken since we want the lesser of the two benefit-cost intersections. The low-x intersection is where diffusion stops, the high-x intersection is where it would start again if it could. We're more interested in the former.

This equation represents Diamond's key insight: availability of information for any society (x_i) depends on the benefit of that information by all societies closer to the innovation (all $x < \bar{x}$).

High-x societies are more likely to have available information in larger networks (y), or if the difference between plots of land (z) is really low. Also, for obvious reasons increasing the cost of adoption decreases the number of societies that end up adopting.

2.7.4 Costs of adoption as endogenous cultural barriers

Think of the cost of adoption (c) being endogenous, and representing a language barrier. So that it's more difficult to acquire information from someone who speaks a more different language.

Societies can maintain linguistic similarity by exploring and communicating with neighbours or they can abandon exploration and drift apart culturally, making discovery of new innovations more difficult. So, maintaining cultural similarity just requires exploring at some cost v. When a society communicates with neighbours, it reduces the cultural distance by some factor (a). This is important to societies because with some probability ρ an exploration trip (E) will result in the discovery of a new innovation (i_x).

The East-West Case

In the east-west case, even though c is endogenous everyone is the same. In other words, c doesn't depend on x. This is straightforward to see.

We have some benefit of exploration B and societies decide how frequently they want to explore:

$$B = E\rho(i - c_x) - vE + ac_xE \tag{2.11}$$
$$\frac{\delta B}{\delta E} = 0 = \rho(i - c_x) - v + ac_x$$
$$c_x^* = \frac{v - \rho i}{a - \rho}$$

Since c_x doesn't depend on x there is no variation in language barriers $(\frac{\delta c_x}{\delta x} = 0)$. Everyone simply chooses to maintain a linguistic distance of $\frac{v-\rho i}{a-\rho}$. In this case the more people would benefit from new information the closer they'll stay, culturally $(\frac{\delta c_x}{\delta i} < 0)$. This is intuitive, there is a large literature arguing that maintaining relationships can be valuable, and this prediction is consistent with that.

One interesting feature of this equation is that the higher the cost of exploration (v), the greater the language barriers $(\frac{\delta c_x}{\delta v} > 0)$. This prediction applies to both the wast-west and the north south cases, and is particularly relevant since it's testable. The implication is that geographic and linguistic isolation should be positively correlated in equilibrium. It seems intuitive that when the linguistic distance is high the benefit of maintaining geographic distance is low and vice-versa. Making both geographic distance and linguistic distance endogenous is beyond the scope of this paper, but the relationship between c and v suggested by equation (2.11) will be tested in the empirical section.

Finally, as expected, when assimilation (a) is easier, they'll remain culturally closer $(\frac{\delta c_x}{\delta a} < 0)$ and since $\frac{\delta c_x}{\delta \rho} = \frac{-(v+ai)}{(a-\rho)^2} < 0$, the greater the probability of making a discovery on any given exploration trip, the closer societies remain culturally.

The North-South Case

The North-South case is only slightly more complicated. Now we simply let i depend on x. Otherwise the benefit function is the same. Recall that $i_x = (zx - y)^2$. Since i_x is not a function of c_x we can just substitute i for $(zx - y)^2$ into the equation for c_x^* above.

$$c_x^* = \frac{v - \rho(zx - y)^2}{a - \rho} \tag{2.12}$$

Everything is the same as before, except now $\frac{\delta c_x}{\delta x} \neq 0$. $\frac{\delta c_x}{\delta x} > 0$ if $\rho > a$ and $\frac{\delta c_x}{\delta x} < 0$ if $\rho < a$.

This means that If $a < \rho$, we would expect an increase in cultural similarity as we get farther away from an innovation, so in this case, if at any point in the future the information was able to get to the south, we would see immediate adoption, as in the case of exogenous adoption costs.

But under the condition $a > \rho$ it may be possible that a failure of any information to diffuse may be permanent, even if all of a sudden the information did become available to the high x societies, who ex ante would have definitely adopted. Because with endogenous cost of adoption the low probability of diffusion associated with having a high x causes the language barrier to rise. In the next subsection we explore how high this barrier would need to get to make diffusion failure permanent.

2.7.5 Permanent Diffusion Failure

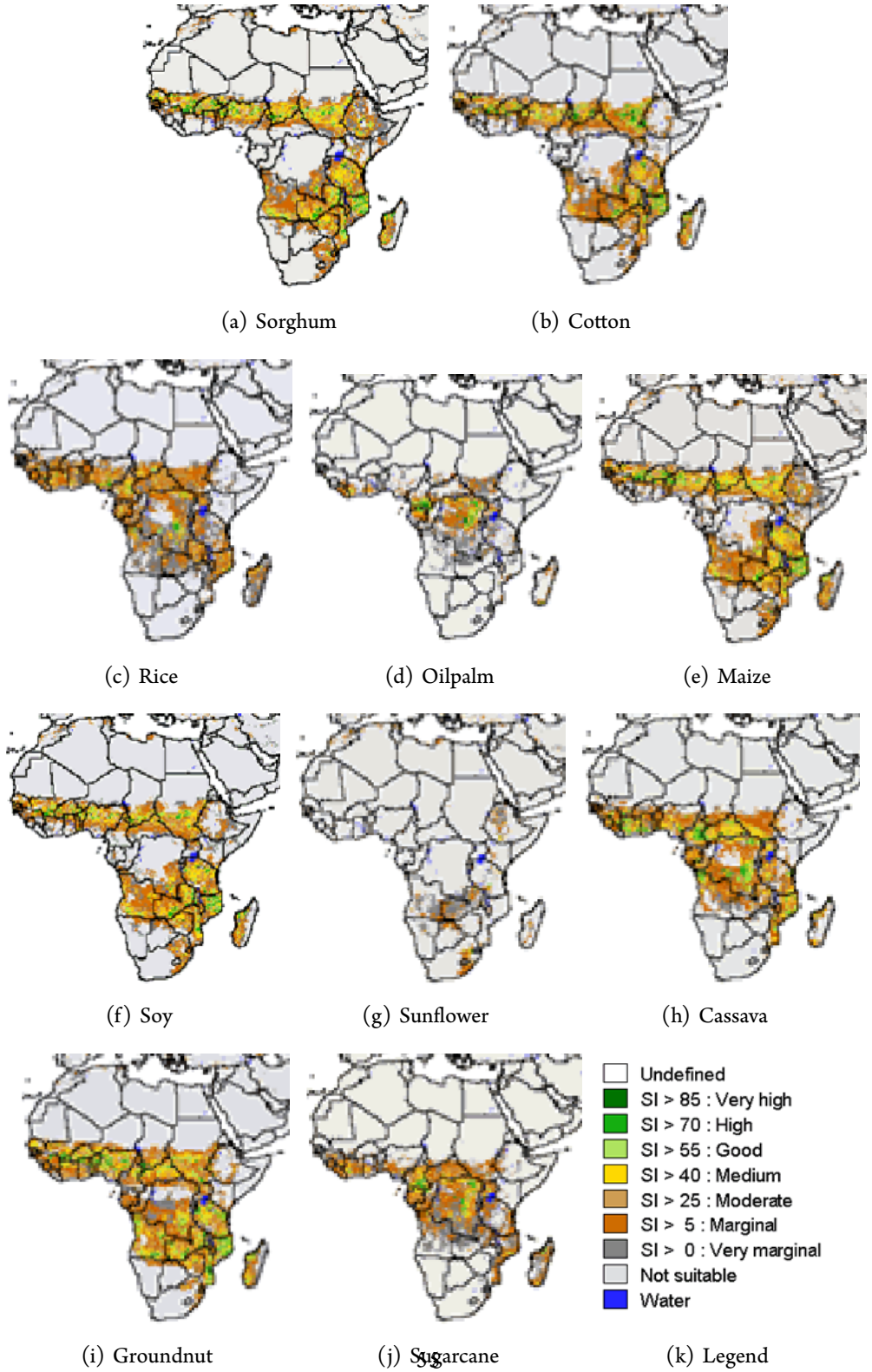
Given that it's possible for the high x societies to culturally drift far away from their neighbours, it is possible that this drift can be so great that the information wouldn't ever diffuse, even if it did reach a societies neighbours.

For permanent diffusion failure, it would need to be true that $\bar{x} < 1$. So from equation (2.10) and (2.12):

$$\begin{aligned} 1 &\leq \frac{y - \sqrt{\frac{v - \rho(z-y)^2}{a-\rho}}}{z} \\ z - y &\leq (-1)\sqrt{\frac{v - \rho(z-y)^2}{a-\rho}} \\ (z-y)^2 &\leq (+1)\Big[\frac{v - \rho(z-y)^2}{a-\rho}\Big] \\ (y-z)^2 &\leq \frac{v}{a} \end{aligned} \tag{2.13}$$

So a diffusion failure can be permanent if the rate of assimilation (a) is low, if the cost of exploration (v) is high, if the distance to the most different society (y) is low or if the proximity of each society (z) to each other is high.

Figure 2.7.2: FAO Suitability Data



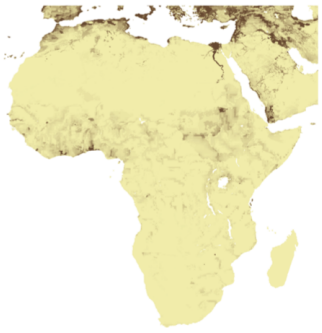
(a) Sorghum (b) Cotton

(c) Rice (d) Oilpalm (e) Maize

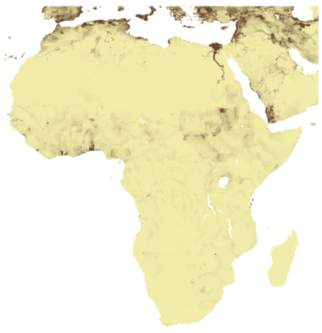
(f) Soy (g) Sunflower (h) Cassava

(i) Groundnut (j) Sugarcane (k) Legend

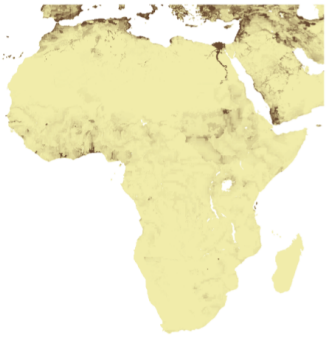
Figure 2.7.3: Klein Goldewijk, Beusen, and Janssen population data at each period: darker regions are more populated



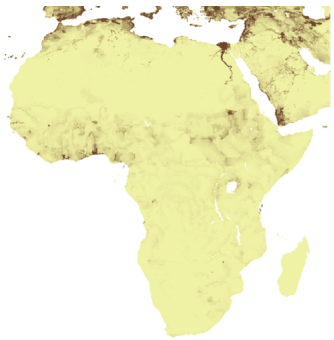
(a) 1000 B.C.E.



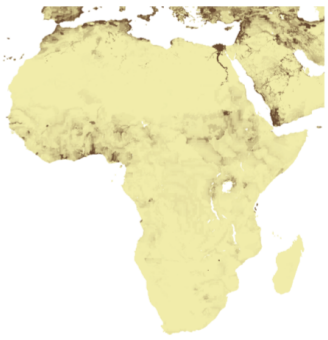
(b) 0 C.E.



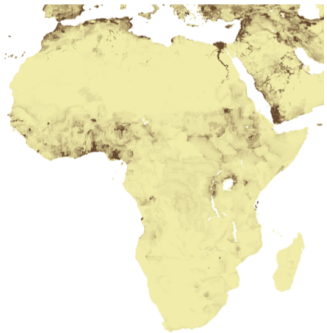
(c) 100 C.E.



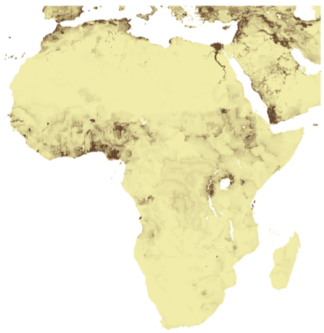
(d) 200 C.E.



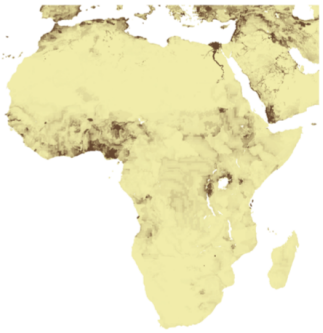
(e) 400 C.E.



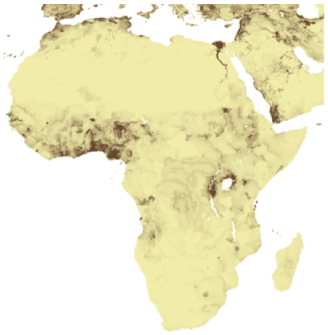
(f) 600 C.E.



(g) 800 C.E.

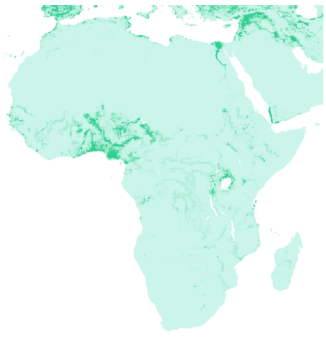


(h) 1000 C.E.

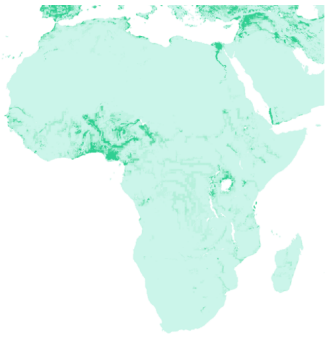


(i) 1200 C.E.

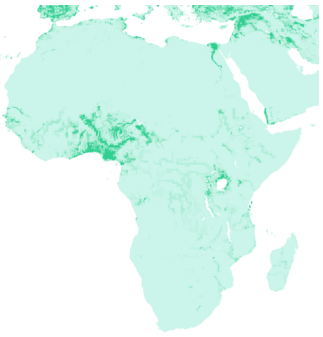
Figure 2.7.4: Historic crop and pastoral land allocation from Klein Goldewijk, Beusen, and Janssen: darker regions are more suitable for pastoral land



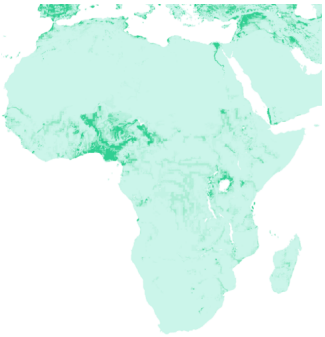
(a) Crops 1500C.E.



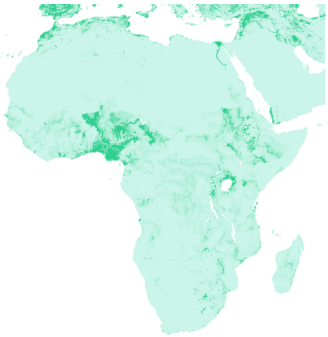
(b) Crops 1600C.E.



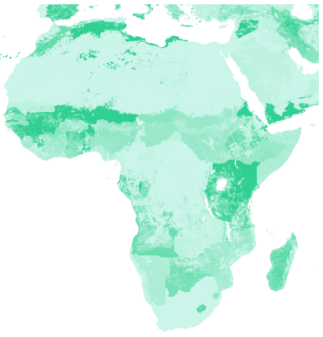
(c) Crops 1700C.E.



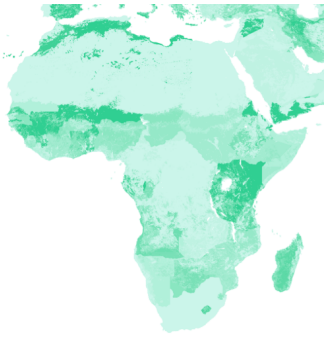
(d) Crops 1800C.E.



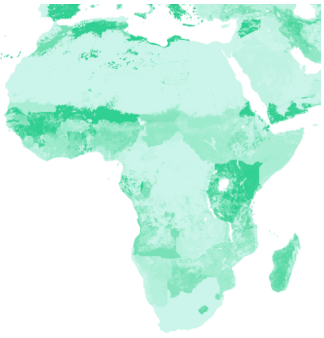
(e) Crops 1900C.E.



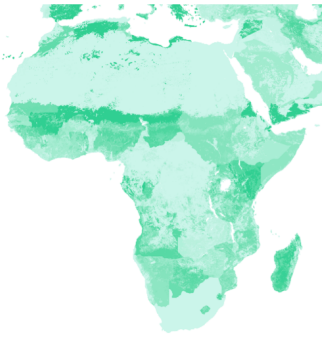
(f) Pastoral Land 1500



(g) Pastoral Land 1600



(h) Pastoral Land 1700



(i) Pastoral Land 1800

(j) Pastoral Land 1900

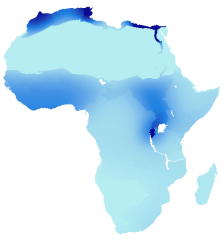
Figure 2.7.5: McEvedy and Jones Population data at each period: darker regions are more populated

(a) 1 C.E.

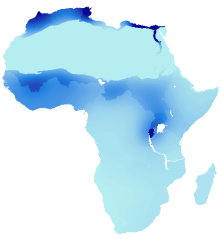
(b) 200 C.E.

(c) 400 C.E.

(d) 600 C.E.

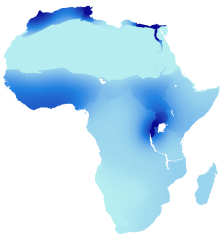


(e) 800 C.E.

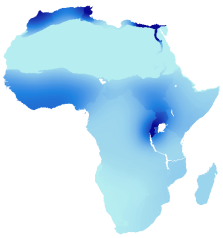


(f) 1000 C.E.

(g) 1100 C.E.



(h) 1200 C.E.

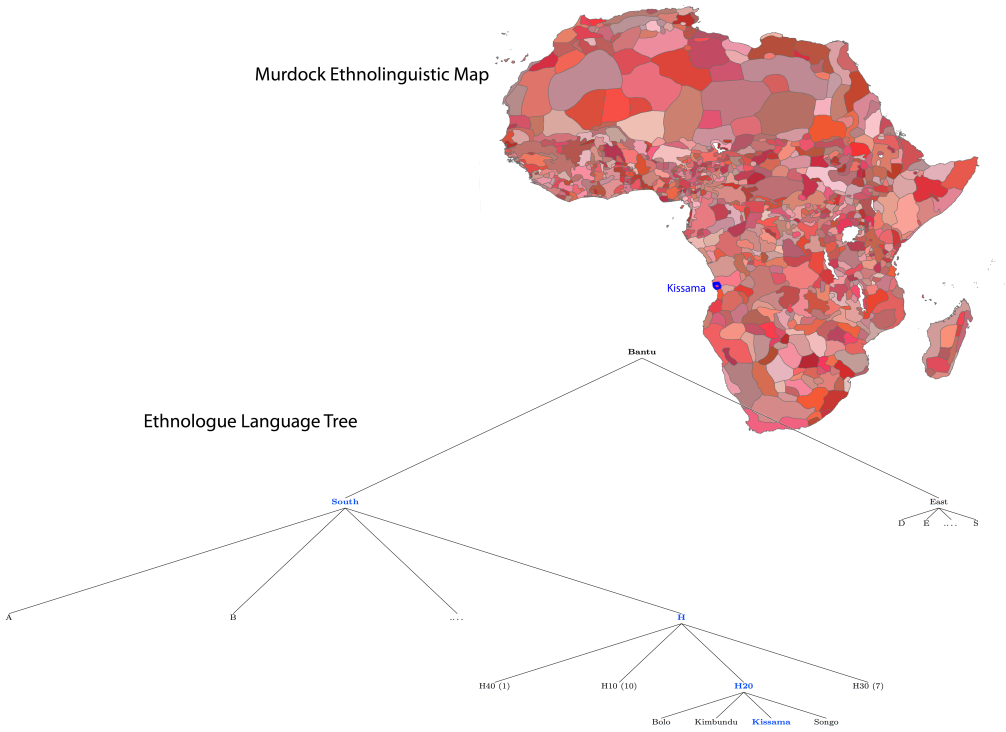


(i) 1300 C.E.

(j) 1400 C.E.

(k) 1500 C.E.

Figure 2.7.6: Example demonstrating how migration routes are assigned to cells



This is an example of assigning migration routes to cells using the Kissama tribe. The Kissama are located on the west coast of tropical Africa and in this example all geographic cells within this region are assigned to the southern route. This is because if we locate the Kissama on the language tree (3rd from the left on the bottom branch shown) and trace back the lineage to the second level of the tree we see a language split analogous to the migration split (East/South). Since the Kissama speak a language most similar to southern migrants, we assume that their ancestors initially migrated south.

Robustness Tables

Table 2.7.8: Impact of a rainforest history on jurisdictional hierarchy

	Jurisdictional Hierarchy Beyond Local Level		Jurisdictional Hierarchy At Local Level	
	(1)	(2)	(3)	(4)
Bantu x South	-0.942**	-0.994***	0.0374	0.126
	(0.356)	(0.361)	(0.381)	(0.370)
Region FE	Y	Y	Y	Y
Crop Suitability FE	Y	Y	Y	Y
Controls	N	Y	N	Y
Observations	1,895	1,895	2,148	2,148
R-squared	0.807	0.811	0.550	0.570

Notes: Standard errors are clustered by ethnicity. Migration partition as described in Flight (1980) is used ({ABCHKLR:DEFGMNPS.}).'Controls' includes land quality, coordinate polynomials, similarity to the rainforest, desert and distance to market.***p<0.01,**p<0.05,*p<0.1.

Table 2.7.9: Impact of a rainforest history on property rights

	(1) Property Rights (general)	(2) Land Rights	(3) Movable Asset Rights	(4) Inheritance Norms
Bantu x South	0.0766	-0.179	0.0766	0.0871
	(0.0512)	(0.110)	(0.0512)	(0.0689)
Region FE	Y	Y	Y	Y
Crop Suitability FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Observations	4,524	4,524	4,524	4,524
R-squared	0.283	0.530	0.283	0.283

Notes: Standard errors are clustered by ethnicity. Migration partition as described in Flight (1980) is used ({ABCHKLR:DEFGMNPS.}).Controls include regionFE, crop suitabilityFE, land quality, coordinate polynomials, similarity to the rainforest, desert and distance to market.***p<0.01,**p<0.05,*p<0.1.

Table 2.7.10: Likelihood of agriculture being occupational choice by migration route

	Dependent Variable: Agriculture as Occupational Choice			
	(1)	(2)	(3)	(4)
Bantu x South	-0.00326***	-0.00584**	-0.0234**	-0.0239**
	(5.51e-05)	(0.00194)	(0.00914)	(0.00921)
Country Fixed Effects	Y	Y	Y	Y
Age	N	Y	Y	Y
Education	N	N	Y	Y
Gender of HH Head	N	N	N	Y
Observations	18447	18447	18443	18440
R-squared	0.131	0.139	0.168	0.168

Notes: Standard errors are clustered by region. Migration partition as described in Flight (1980) is used ({ABCHKLR:DEFGMNPS.}).***p<0.01,**p<0.05,*p<0.1.

Table 2.7.11: Altonji Ratios Assessing Selection on Unobservables

Crop	Estimate (full)	Estimate (restricted)	Altonji Ratio
Sorghum	-0.790	-0.967	4.46
Cotton	-0.258	-0.327	3.74
Soy	-0.0523	-0.0739	2.421
Maize	-1.98	-3.156	1.684
Sunflower	-0.144	-0.280	1.059
Cassava	-0.413	-0.392	19.667
Groundnut	-0.335	-0.397	5.403
Sugarcane	-0.0655	-0.0819	3.994

*The results of the full sample are reported in table 2.7.4
*The restricted sample includes controls for latitude and longitude as well as Bantu and the variable of interest: Bantu x Southern Route (reported)

Table 2.7.12: Robustness Check: Modern Crop Production by Crop Class Representative

VARIABLES	(1) Sorghum (dry-traditional)	(2) Rice (wet-traditional)	(3) Maize (dry-post colonial)	(4) Groundnut (wet-post colonial)
Bantu x South	-2.127***	-0.354	-1.706***	-2.776***
	(0.441)	(0.421)	(0.607)	(0.466)
Latitude and Longitude controls	YES	YES	YES	YES
Education Fixed Effects	YES	YES	YES	YES
Suitability Fixed Effects	YES	YES	YES	YES
Age and Gender Controls	YES	YES	YES	YES
Distance to Metropolitan Centre	YES	YES	YES	YES
Exposure to Slavery	YES	YES	YES	YES
Observations	8553	8553	8553	8553
Number of Clusters	718	718	718	718
R-squared	0.59	0.46	0.49	0.60

Notes: Standard errors are clustered by village. Migration partition as described in Flight (1980) is used ({ABCHKLR:DEFGMNPS.}).***p<0.01,**p<0.05,*p<0.1.

Figure 2.5.1: Speed of Migration Frontier Entering (left) and Exiting (right) the Rainforest Using Klein Goldewijk, Beusen, and Janssen (top) and McEvedy and Jones (bottom) Data

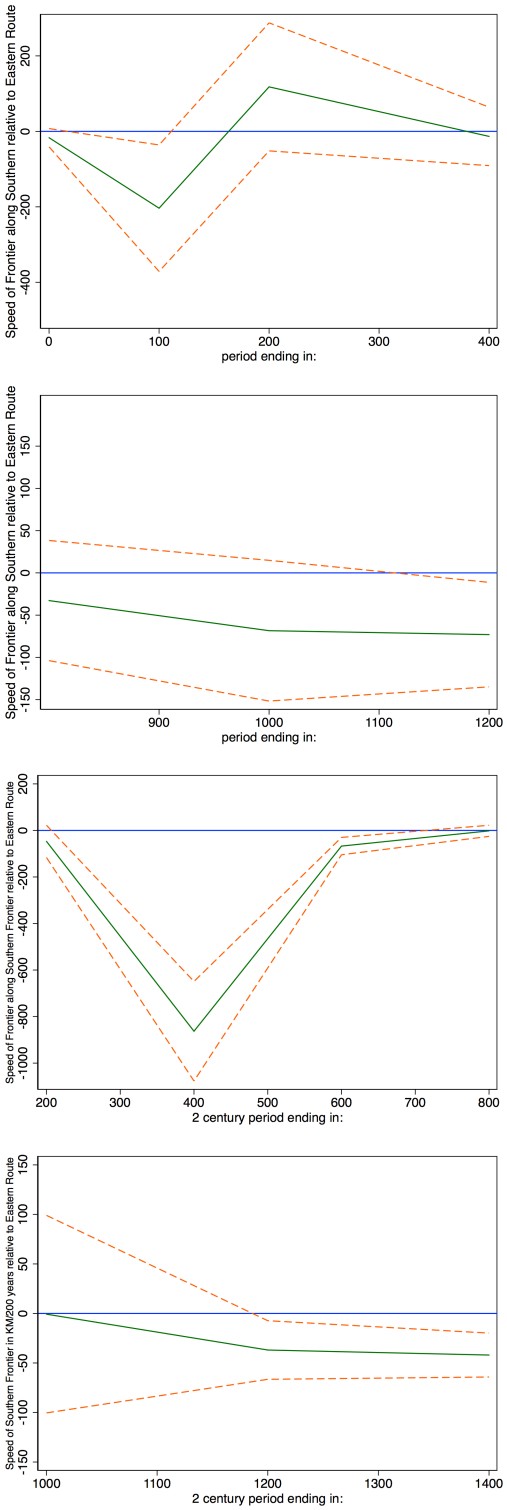
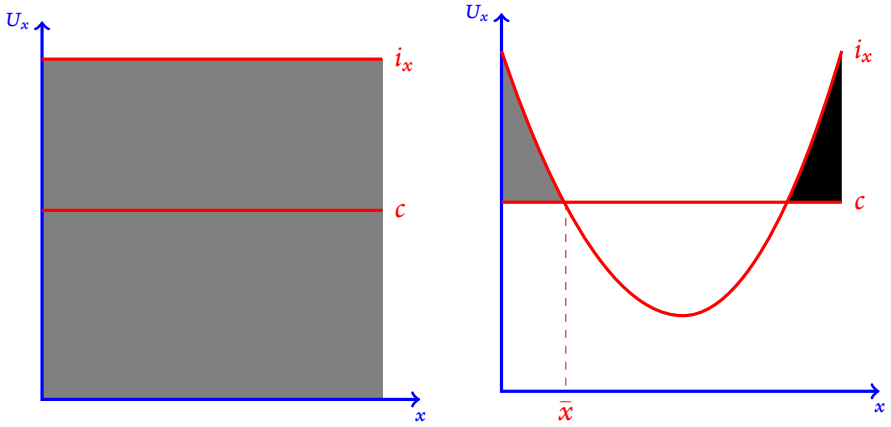


Figure 2.7.1: Diffusion depends on axis-orientation



(a) Case 1: East-West Axis

(b) Case 2: North-South Axis

Description: i_x represents the benefit of acquiring information and c represents the cost. x is the nodal location of a society. The grey regions actually acquire the information and benefit from it. The dashed-gray region would benefit from the information, but it is not available to them so they do not acquire it.

3

Tropical Lending: International Prices, Strategic Default and Credit Constraints among Coffee Washing Stations

3.1 Introduction

Developing countries are poorer largely because they are less efficient at allocating factors of production across different uses (Banerjee and Duflo (2005) and Hsieh and Klenow (2009)). Imperfections in the credit markets, in particular, are believed to be an important source of misallocation of capital both across sectors (see, e.g., Buera et al. (2009)) as well as across firms within sectors (see, e.g., Banerjee and Munshi (2004)). Consistently with this view, an active empirical literature has documented high and extremely heterogeneous returns to capital among microenterprises in a variety of contexts (see, e.g., De Mel et al. (2008), Fafchamps et al. (2011), Kremer et al. (2010), Karlan et al. (2012)).

To fully understand the role of credit market imperfections in constraining

efficiency in developing countries and provide guidance to design appropriate policy responses, however, the existing evidence must be complemented in two important ways. First, sources of imperfections must be identified in specific settings (see, e.g., Paulson et al. (2006)).[1] Second, the relevance of credit constraints must be assessed among larger firms, where most capital is invested. Relative to the empirical literature discussed above, however, progress in both directions has been significantly more limited. Disentangling sources of credit market imperfections requires exogenous variation in incentives (see, e.g., Karlan and Zinman (2009)) while testing for credit constraints requires exogenous variation in capital (see, e.g., Banerjee and Duflo (2008)). Both sources of variation are rarely available to the econometrician, particularly since experimental approaches are impractical when studying large firms.

This paper contributes to our understanding of the sources and consequences of credit constraints among large firms in developing countries using coffee washing stations as a sector study. The paper exploits comprehensive data from an international lender on a portfolio of working capital loans to around two hundreds coffee washing stations in eighteen countries. Besides the richness of the data, the sector provides an ideal set-up to overcome the challenges highlighted above. First, the stark separation in the timing at which contracts are signed (pre-harvest), loans disbursed (during harvest) and sales realized (post harvest) can be combined with unanticipated fluctuations in international coffee prices to test for, and distinguish, ex-ante and ex-post moral hazard. Second, knowledge of the relatively simple technology of coffee washing stations enables a transparent test for credit constraints.

[1]The theoretical literature on sources of credit market imperfection is vast. Stiglitz and Weiss (1981) is the classical reference on adverse selection. Holmstrom and Tirole (1997) and Burkart and Ellingsen (2004) emphasize ex-ante moral hazard in the form of private benefits (effort) and loan diversion respectively.Lacker and Weinberg (1989) and Ellingsen and Kristiansen (2011) emphasize ex-post moral hazard: due to costly monitoring and/or contract incompleteness borrowers strategically default on loan obligations. Besley (1995) and Ghosh et al. (2000) provide useful discussion in a development context.

The test is based on a regression discontinuity design in which essentially identical loan applications end up with loans of different size.[2]

After describing the sector and the data sources, we present a simple theoretical framework of the lending model used by our lender to extend working capital loans to coffee washing stations. The lender provides working capital loans to coffee washing stations around the world based on a system of account receivables in which sales contracts with foreign buyers are used as collateral.[3] The model emphasizes limited contract enforcement and uncertainty over output prices, two salient features of the environment under consideration. The model shows that unanticipated ex-post increases in world prices increase the likelihood of default only if ex-post moral hazard, i.e., strategic default, is present. The associated incentive compatibility constraint clarifies how contract level data on loans and sales can be combined to quantify the value of informal enforcement.

The empirical analysis is divided in two parts. First, we investigate the determinants of loan default and find evidence of strategic default (ex-post moral hazard). Unanticipated increases in international coffee prices just before the loan maturity date significantly increase the likelihood of delayed payments and defaults. Consistently with the predictions of the model, price increases lead to defaults when the station has entered fixed price contracts with the foreign buyer and when there is no previous history with the lender. These results hold across a number of different specifications and samples, including an event-study methodology.

Given the evidence of ex-post moral hazard, we provide a simple calibration of the

[2]Besides the advantages from a research design point of view, the coffee sector is important in its own right. Coffee is produced by an estimated 30 million farmers in more than thirty low income countries, for which is often one of the main sources of exports. The sector provides an ideal canvas to study aspects that are relevant in the financing of other export oriented sectors in developing countries (e.g., cotton, pineapple, vanilla, cocoa, cashew).

[3]The lender is well aware of the difficulties of extending loans to large firms based in rural areas of developing countries. See next section for details.

associated ex-post incentive compatibility constraint to assess the importance of informal enforcement, intended as the value of the relationship with the lender and foreign buyer. We derive lower (upper) bounds to the value of informal enforcement for repaying (defaulting) borrowers. We find this value to be large: it is at least (most) 54% (21%) of the value of sales for repaying (defaulting) borrowers on average.

Despite the lending arrangements put in place by our lender, evidence of strategic default implies that borrowers are likely to be credit constrained. The second part of the empirical section implements a regression discontinuity design to test for the presence of credit constraints. Discontinuity in the assignment of loan applications to a summary score category induces exogenous variation in loan size among otherwise identical loan applications. We find that stations use the additional funds to purchase more inputs from farmers rather than substituting other, potentially more expensive, sources of loans. We estimate mean returns to capital to be in the order of 32%, well above the interest rate charged by lenders (about 10%). These two pieces of evidence confirm that firms in the sample are severely credit constrained. We find that the relationship with the lender accounts for roughly a half of the value of informal enforcement. Furthermore, we also find evidence that larger loans lead to higher prices paid to farmers supplying the stations. This implies the existence of contractual externalities and a possibly sub-optimal level of integration along the value chain.

In sum, the study provides evidence on the sources (ex-post moral hazard) and consequences (credit constraints along the supply chain) of credit market imperfections among relatively large firms in developing countries. As further discussed below, the contractual practices adopted by our lender already mitigate sources of credit market imperfections, including those for which we find direct evidence. Therefore, our study identifies a lower bound to the cost of credit market imperfections. We discuss policy implications of all these findings in the concluding

section.

Related Literature

This paper contributes to the literature on credit markets and firms in developing countries. The most closely related contribution is Banerjee and Duflo (2008) who exploit records from an Indian bank and natural experiments induced by changes in priority-lending regulations to identify credit constraints. The regression discontinuity design test for credit constraints in our paper is similar in spirit to their approach. However, in this paper we also identify sources of credit market imperfections and quantify the value of informal enforcement.[4]

The setting of our study brings this paper close to an emerging literature on the financing of export transactions (see, e.g., Paravisini et al. (2011) and Manova (2013)). The most closely related work is Antras and Foley (2011) who study contractual credit terms between a large exporter of frozen food and foreign distributors. Banerjee and Duflo (2000), Macchiavello (2010) and Macchiavello and Morjaria (2013) also study contractual relationships in export markets and emphasize the importance of reputation and informal enforcement in a variety of different contexts. In contrast to these papers, we simultaneously consider relationships with both buyers and lenders and document contractual externalities along the value chain.[5,6]

[4]The literature on testing for asymmetric information has been mostly developed in the context of insurance markets (see, e.g., Chiappori and Salanié (2002) for an early review). In the context of credit markets, Karlan and Zinman (2009) provide an experimental study of personal loans in South Africa while Adams et al. (2009) study the subprime lending in the U.S.

[5]The corporate finance literature has studied several aspects that characterize our environment. For example, Klapper (2006) examines factoring while Klapper et al. (2012) examine a large sample of trade credit contracts. The paper is also related to a literature on the relationship between risk management and credit constraints. Rampini et al. (2011), for example, provide an empirical analysis for the case of airlines.

[6]Nunn and Dragusanu (2013) study the impact of fair trade certification in the Costa Rica coffee sector. de Janvry et al. (2010) provide a theoretical and empirical analysis of fair trade certification using data from a secondary cooperative in Guatemala. Adhvaryu et al. (2013) examine the impact of international price fluctuations on farm activity in Tanzania. Casaburi and Reed (2013) study price

The rest of the paper is organized as follows. Section 2 describes the coffee industry, its contractual practices, and the data. Section 3 introduces the model and derives testable predictions. Section 4 presents the empirical results. Sections 5 discusses policy implications. Finally, Section 6 offers some concluding remarks. Proofs, additional results and further information on the data are relegated to the Appendix.

3.2 Background

Coffee Washing Stations

The coffee cherry is the fruit of the coffee plant. The cherries are ripe when they change colour from green to red, at which point they should be harvested. The harvest season typically lasts for three to four months. The timing of the harvest season varies by country and, within country, by region depending on altitude, soil and rainfall patterns. Most coffee-growing countries have only one major harvest a year. In most countries, the coffee cherries are picked by hand, a labor-intensive and difficult process.

The pulp of the coffee cherry is removed leaving the seed or bean which is then dried to obtain parchment coffee. There are essentially two processing methods to obtain parchment coffee: the dry method and the washed method. The dry method, also known as unwashed or natural, has the entire cherry first cleaned and then placed in the sun to dry on tables. This process is done by farmers. In the washed method, instead, farmers bring coffee cherries immediately after harvest to a washing station, the firms that are the objects of our study. The washed method requires specific equipment and substantial quantities of water. After the cherry skin and some of the pulp are removed with a pressing machine, cherries are then sorted by immersion in water. The bean is then left to ferment, typically for around 30 hours, to remove the

pass-through with an experiment in the Sierra Leone cocoa sector.

remaining skin. The fermentation process has to be carefully monitored to ensure that the coffee doesn't acquire undesirable, sour flavours. When the fermentation is complete, the coffee is thoroughly washed with clean water in tanks or in special washing machines. The beans are then dried in the sun (and sometime with the further help of machines). Coffee dried in the sun is spread out in rows on large tables or on patios where it is frequently turned by hand or raked. Drying coffee on tables improves quality but increases cost and labor significantly. After the drying process the parchment skin is easily removed in the hulling process. Essentially all coffee is hulled before shipment.

The method used to process the cherries has a significant effect on the flavour of coffee once roasted and brewed. The wet method delivers higher consistency and quality which is reflected in prices. Data from Rwanda available to the authors, for example, reveal that washed coffee is sold at two and half to three times higher price than dry coffee both as parchment in the domestic market and as green coffee at the export stage.

Despite having seasonal activities tied to the coffee harvest season, coffee washing stations are large firms by developing country standards. In our sample, stations average over 2.4 million dollars a year in sales, hold almost 1.4 million in total assets (see Table 4.6.1) and receive an average loan size of around 345,000 dollars from our lender.[7]

An important aspect of our environment is the relatively simple, and known, relationship between input and output. The quantity of output (parchment coffee) is a constant share, ranging between one fifth and one seventh, of the quantity of input (coffee cherries). That is, within the capacity limits imposed by the fixed assets invested in the station (e.g., the pulping machine, drying tables), there is a constant

[7]By comparison, the firms in the sample in Banerjee and Duflo (2008) average 140,000$ in sales and 17,000$ in loan amout.

return relationship between coffee input and output. Disbursement to purchase coffee cherries from the farmers during the harvest season are, by far, the largest source of variable costs. These, generally, account for sixty to seventy percent of the overall costs. Other costs include labour, transport, electricity, marketing and, of course, costs of finance. Large volumes of working capital need to be mobilized over short periods of time in environments characterized by institutional underdevelopment. Furthermore, the environment is characterized by significant uncertainty, particularly with respect to fluctuations in international prices.

Contractual Practices I: Loans

We obtained access to the internal records of an international lender specialized in providing working capital loans to coffee washing stations. The data cover all loans ever disbursed by the lender over a period of twelve years for a total of 756 loans, of which 669 are for working capital. The one hundred ninety seven coffee washing stations are located in eighteen countries, with Peru, Mexico, Nicaragua, Rwanda and Guatemala accounting for the majority of loans.

The lender is highly aware of the difficulties in extending working capital finance to large, seasonal, business operating in rural areas of developing countries, often characterized by a relatively poor institutional environment. Consequently, the lending model is explicitly designed to cope with issues of adverse selection and moral hazard. In particular, our lender utilizes a comprehensive scoring system to rate loan applications and decide the size of the loan disbursed. The lender also disburses loans progressively and actively monitors the use of the loans. More importantly, from the point of view of the research design, lending is based on account receivables as explained in detail below.

The borrowers in the sample mostly supply the coffee specialty market. In this segment, coffee washing stations supply coffee directly to foreign buyers (which

might be roasters or traders) with whom they develop informal relationships. The lending model, which is based on an account receivable system, is structured as follows. First, before the harvest begins the buyer signs a contract, or a letter of intent, with the station for the delivery of a certain amount of coffee of pre-specified quality at a later date. The lender, who has a relationship with the buyers, then advances a share of the value of the contract with the buyer to the station. The share depends on a scoring system. The scoring systems aggregates continuos sub-scores based on a large number of station and loan characteristics into discrete categories (B, A, AA). The share extended to the station typically varies between 40% and 70% of the value of the contract with the buyer. Upon delivery of the coffee, the foreign buyer notifies the lender which is then repaid (typically directly by the buyer).

This lending system is not unusual.[8] The arrangement used by our lender is essentially identical to invoice discounting in which the receivable is used as collateral for the loan.[9] Because the credit provided by the lender is explicitly linked on a formula basis to the value of a supplier's accounts receivable (in addition to the supplier's overall creditworthiness), the system allows relatively high-risk exporters in developing countries to borrow against the value of their contracts with high-quality buyers in developed importing countries. By establishing direct contractual relationships with the buyers, our lender ensures that the loan is repaid if the coffee is delivered to the buyer. In other words, in order to default on the loan, the station also

[8]Bank loans secured by accounts receivable are the primary source of SME financing for working capital in the US. Beck et al. (2002) note that credit between buyers and suppliers is relatively more prevalent in countries with weak legal environments and we, therefore, conjecture that account receivables (or similar contractual arrangements) are an extremely common source of finance for SMEs in developing countries.

[9]Invoice discounting is similar, but different from, factoring. The key distinction is that in factoring a business *sells* its accounts receivable to a third party (called the factor). The factor provides financing in the form of a cash advance (often 70-80% of the purchase price of the accounts), with the balance of the purchase price paid, net of the factor's fee and other charges, upon collection from the account client. Around the world, factoring is a growing source of external financing for small and medium-size enterprises (SMEs) (Klapper (2006)).

has to default on the sale contract with the foreign buyer. While formal enforceable contracts are typically not used, the loss in reputation and future sales from the buyer is a powerful deterrent towards this type of default.[10]

Contractual Practices II: Sale Contracts

Given the lending arrangement used by our lender, it is important to describe the basic incentives associated with sales contracts. The international trade in coffee is based upon a number of standard contractual forms. The two most frequently used are those issued by the European Coffee Federation (ECF) and by the Green Coffee Association (GCA) in the United States. The basic conditions of sale are easily covered by stipulating the applicable standard form. Parties fill the standard form with the remaining important details of the individual transaction (quantity, quality, price, ...). From the point of view of our research design, the key distinction is between trade at fixed (or 'outright') price versus trade at a 'differential' (or 'price to be fixed' (PTBF)).

Before active futures markets came into being coffee was bought and sold at fixed prices, meaning purchase and sale contracts would show a simple amount per pound or per ton. Fixed price contracts expose parties to significant price (and counterpart) risk. An importer who buys coffee that has not already been sold (bought long) hopes that the price will stay the same or go up. An exporter who sells coffee that has not already been bought (sold short) hopes that the price stays the same or goes down.

With the development of future markets coffee has increasingly been bought and sold on a 'differential basis' (or PTBF contract). In this type of sale, the seller (buyer) commits to deliver (take) a certain amount of coffee not at a fixed price but at a

[10]It is common practice for exporters of agricultural commodities in developing countries to enter into pre-financing arrangements with importers (see, e.g., Larson and Varangis (2006)). For example, survey data available to the authors reveal that loans from large domestic exporters represent the only source of working capital finance for 40% of Rwandese coffee washing stations (see, Macchiavello and Morjaria (2013) for details).

difference to a basis price. Theoretically the basis price can be any published price in the coffee business but, in practice, almost all differential contracts are signed against futures markets (i.e., Robusta coffee is traded against the London LIFFE Contract while Arabica coffee, the object of this study, is traded against the New York ICE 'C' Contract). The main advantage of future markets is their liquidity which allows prices to be fixed anytime these markets are open for trading. Trading on a 'differential' basis changes price risk from 'outright' price to 'differential' price risk. Although 'differential' price risk is inherently lower, it is important to note that PTBF contract does not eliminate price risk.[11]

An important aspect of the PTBF contract is the date at which the buyer and seller can fix their respective prices. In the context of our analysis, which focuses on direct exports from coffee washing stations to foreign buyers without the intermediation of traders, exporters typically do not have access to future markets. As a result, the PTBF contracts tend to stipulate a 'seller's call clause according to which the seller calls the date at which the price ought to be fixed. In principle, this allows the exporter to achieve grater insurance by fixing the price shortly after the purchase of the coffee cherries necessary to fulfill the sale contract.[12]

Descriptive Characteristics: Firms, Loan and Sale Contracts

The loans data begins in 2000 and ends in 2012, totalling 753 loans from 197 clients. The lender decides on loan terms using a scoring system. Scores are assigned to multiple sub-groups, which are aggregated into category scores, which themselves are aggregated into overall numerical scores which is the basis for the assignment of a

[11]The Coffee Export's Guide published by the International Trade Centre, for example, describes how in 2010 some Colombian coffees which had been trading at around ICE 'C' plus 15 cts/lb, went up to ICE 'C' plus 80 cts/lb. Differential price risk is relatively stronger in the specialty coffee segment of the market, where differentials are fine tuned to relatively narrower origins with less liquid markets.

[12]Stations can, however, misuse and attempt speculation by either i) fixing PTBF contracts without actually having bought the physical coffee, or ii) delaying fixing until long after the physical coffee was bought hoping for a price recovery.

letter score (B, A, AA). The lender has disaggregated score data starting late 2008. Prior to 2008 the numerical score data was calculated and used in the same way, but not stored systematically. As a result, there are 291 loans for which disaggregated score data exists.

Whenever a loan is given the lender assembles income sheet and balance sheet data for the client for the previous three years. From this data we constructed a panel of financial information at the station level which yields 657 station-year observations. The panel includes the three years prior to the closing year for all loans. For clients that received loans in later years it includes financial information for a number of years after the loan was dispersed, depending on whether the client signs loan agreements with the lender in subsequent years.

Table 4.6.1 displays descriptive statistics for both the loan level data and the client-loan panel. The average loan in the sample is just over 340,000 USD, while the average interest rate is about 9.8%, ranging from 7% to 18%. About 30% of loans in the sample are repeat clients, and default rates are low. On average only 3% of loans are written off, while about 6% are either written off, restructured or significantly late with payment. The world coffee price increased over the majority of the sample period. The price rose from about 165 USD in late 2004 to about 340 USD in late 2009. The price reaches a high of 636.54 USD in late 2011 and declines slightly in 2012. On average the price in our sample period was just under 350 USD and increased by nearly 14% over the life of the average contract.

Firms in our sample are very large by developing countries standards. Mean total assets are over 1.5 million USD, however median total assets are about half of that, so we have a few extremely large firms in the sample. Most firms receiving loans from our lenders have other loans from either other financial institutions or buyers. Income is high, over 2.5 million, but cost of goods sold is about 85% of total income.

Firms employ about 135 people in a year on average, nearly three quarters of which are seasonal employees.

3.3 Theory

3.3.1 Set Up

We consider the relationship between a coffee washing station (station), a lender and a foreign buyer modeled to capture the most salient features of our environment. The station has capacity to process, and produce, Q units of coffee. We denote with q^c the quantity that the station commits to deliver to the buyer. The price, p^c, is discussed later. We assume that the only source of cost for the station is the purchase of cherries from the farmers. The price of cherries is denoted p_o and is fixed and known to all parties. For simplicity, we set the risk-free interest rate to zero and denote by L the amount lent to the station and by D the amount the station commits to repay. The station is subject to limited liability, i.e., at all dates the payoff of the station must be positive. A delivery failure imposes an arbitrarily high penalty K on the buyer.

The timing of the game is as follows:

1. The buyer and the station agree on the sale contract: $q^c \leq Q$ and the price (to be specified later). We assume that the buyer has all the ex-ante bargaining power and makes a take-it-or-leave it offer to the station. If the station rejects the offer, the station can still produce using internal funds I and sell in the market as described below.

2. The station then negotiates the loan terms (L and D) with the lender. The station now has all the bargaining power and the lender is subject to a zero profit constraint.

3. The loan is disbursed and the station decides whether to divert the loan, or use it to purchase the cherries necessary to fulfill the sale contract.

4. Fourth, the price in the international market, p, is realized. The price in the market at the time of sale is drawn from a continuos distribution $F(p)$, with $\overline{p} = \mathbf{E}[p|p_0] = \int_0^\infty p dF(p)$.

5. The station decides whether to execute the sale and repay the loan or whether to search for an alternative buyer who pays price $p' = p$ and avoid repayment. Conditional on search, an alternative buyer is found with probability μ. If a buyer is not found, the firm can still sell to the original buyer and repay the loan with a delay.

3.3.2 Benchmark: First Best

We consider first the case in which all contracts are perfectly enforceable. Without loss of generality, let's focus on a fixed price contract p^c and solve the game backward. The realization of the price p has no effect on the execution of the sale.[13] Assuming the station has been able to finance the production of a quantity $Q^p \leq Q$, the revenues of the station are given by

$$\Pi\left(q^c, p^c, p\right) = \begin{cases} q^c p^c + p\left(Q^p - q^c\right) & \text{w.p. } \mu \\ q^c p^c & \text{w.p. } (1-\mu) \end{cases}. \tag{3.1}$$

In either case, the station repays the amount D to the lender, or the entire value of the sales if this is lower. For the lender to make zero profits in expected terms, we

[13] The costs incurred by the buyer for a delivery failure, K, are assumed to be larger than $\mu q^c\left(p - p^c\right)$, the expected gains of searching for an alternative buyer.

must have

$$L \leq q^c p^c + \mu \left(Q^p - q^c \right) \overline{p}. \tag{3.2}$$

Given a contract q^c and p^c and internal funds I we also have

$$I + L \geq p_\circ Q^p. \tag{3.3}$$

The station borrows to produce at full capacity if

$$\mu \overline{p} \geq p_\circ \tag{3.4}$$

which we assume to be the case. The station, therefore, borrows $L = p_\circ Q - I$. At time of contracting with the buyer, therefore, the station's outside option is given by

$$u^\circ = \left(\mu \overline{p} - p_\circ \right) Q.$$

In order for the buyer to enter any contract, it must be that its willingness to pay, $v\left(q^c\right)$, is higher than $\mu \overline{p}$ for at least some quantity q^c. To simplify, we assume that $v\left(Q\right) \geq \mu \overline{p}$ and hence $p^c = \mu \overline{p}$ and $q^c = Q$.

3.3.3 Fixed Price Contract

When contracts are not enforceable, incentive compatibility considerations must be taken into account. We begin by considering the case in which a fixed price contract has been signed and, again, solve the game backward. We focus on the case in which the amount lent by the lender is lower than the face value of the contract with the buyer, i.e., $q^c p^c \geq D$. Upon observing the realized value of p, the station repays

without further delays if

$$q^c p^c - D + \mu p\left(Q^p - q^c\right) + \delta \mathbf{V} \geq \mu\left[pQ^p + \delta \mathbf{U}^D\right] + (1-\mu)\left[q^c p^c - D + \delta \mathbf{U}^L\right] \quad (3.5)$$

where $\mathbf{V}$ is the discounted value of future expected profits when continuing the relationship with the buyer *and* the lender, $\mathbf{U}^D$ is the discounted value of future expected profits following a default and $\mathbf{U}^L$ is the discounted value of future expected profits when paying late. We assume $\mathbf{U}^D = \mathbf{U}$ and $\mathbf{U}^L = \sigma \mathbf{V} + (1-\sigma)\mathbf{U}$ where σ is the probability the loan is renewed following a late payment. The second assumption implies that *i*) the continuation value following a late payment only depends on whether the loan is renewed or not and *ii*) conditional on no future loan, the continuation value does not depend on loan default. We leave $\mathbf{V}$ and $\mathbf{U}$ unmodeled. The incentive compatibility constraint can be rewritten as

$$\delta(\mathbf{V} - \mathbf{U}) \geq \left(\frac{\mu}{1 - \sigma(1-\mu)}\right) \times \left(D + (p - p^c) q^c\right). \quad (3.6)$$

The station decides to search for an alternative buyer and default for *i*) lower value of the relationship with the buyer and lender, *ii*) higher values of debt D, and *iii*) higher value of the realized market price p. This positive dependence of the likelihood of default on ex-post market price realization provides the test for strategic default.[14] The probability of a default, therefore, is given by

$$\Phi^d\left(D, p^c, q^c\right) = \mathbf{P}(p \geq p^d) = \mu\left(1 - F\left(\frac{\delta(\mathbf{V} - \mathbf{U}) - D + p^c q^c}{\mu q^c}\right)\right) \quad (3.7)$$

Loan diversion is easier to be deterred for *i*) lower debt levels D, *ii*) higher prices paid by the buyer p^c, and *iii*) higher values of expected future prices $\overline{p}$ (since $Q^p \geq q^c$

[14] To examine the dependence of the likelihood of default on q^c we need to consider that D also depends on q^c.

by definition).[15]

3.3.4 Summary of Predictions

The main implications we bring to the data are:

Test 1: [**Ex-ante Moral Hazard**] *Sudden increases in expected future prices at the time of contracting reduce the likelihood of default;*

Test 2: [**Ex-post Moral Hazard**] *In the presence of strategic default, sufficiently large unanticipated increases in ex-post world prices lead to higher likelihood of default;*

Test 3: [**Informal Enforcement**] *Data on the face value of debt D, sale contracts p^c and q^c and world prices μ can be used to recover lower (upper) bounds to the value of the relationship $\delta(\mathbf{V} - \mathbf{U})$ for repaying (defaulting) borrowers using (3.6).*

3.4 Empirical Results

The empirical section is divided into two parts. The first section exploits the impact of international coffee price movements to test for the presence of moral hazard. The section mainly focuses on ex-post moral hazard, i.e., strategic default, and provides a simple calibration of the ex-post incentive compatibility constraint (3.6) to bound the value of informal enforcement in this market. The second section implements a regression discontinuity design to test for the presence of credit constraints.

[15] The contract must also satisfy the ex-ante incentive compatibility constraint: the station must prefer to invest the borrowed amount rather than diverting the loan. It is easy to show that sudden increases in the expectation of future prices immediately after contracting time increase the incentive to use the loan to produce.

3.4.1 Strategic Default

Cash Flows and Contract Timing

The typical cash flow profile for a station during a year is illustrated in Figure 3.6.1 (using the case of Rwanda as an example). Sales and loan contracts are typically negotiated and signed around the beginning of the harvest season (in the Rwanda case, around March). The loan is then disbursed, possibly in multiple instalments, to cover the costs of purchasing cherries from the farmers. During the harvest season, stations buy cherries from farmers and process them. The contract typically matures after the end of the harvest season (i.e., after July).

An important advantage of the setting is that the timing of the harvest season is not synchronized across countries (and, to some extent, even across regions within countries). For example, most contracts in Peru (which represents 34% of the loans in the sample) are closed in the period May to June while in Nicaragua (which accounts for 11% of the loans in the sample) most contracts are closed in October to December. In Rwanda (which accounts for 8% of the loans in the sample) most contracts are closed around March to April. Figure 3.6.2 shows seasonality patterns in the closing and maturity dates of loan contracts in the sample. The closing date (blue lines) refers to the month in which the loan contract is signed. The maturity date (red line) refers to the date at which the loan is supposed to be repaid (which typically falls at or close to the delivery date in the sale contracts). The Figure illustrates the bimodal distribution of both closing and maturity dates with two peaks in each distribution driven by asynchronous coffee harvest seasons across countries. Variation in the timing of the harvest seasons and, therefore, of closing and maturity dates across countries allows us to control for time fixed effects in a flexible way in all the empirical specifications.

Baseline Test for Strategic Default

Figure 3.6.3 presents a graphical approach to test for the presence of ex-post moral hazard. Recall that the key test for strategic default is that unanticipated increases in the world price of coffee before the maturity date increase the likelihood of default. A distinctive advantage of the set up is given by the presence of liquid future markets. Futures prices quoted at the time of the closing date for the maturity date provides an unusually good proxy for parties expectations of future prices. Figure 3.6.3 shows the relationship between unanticipated increases in international coffee prices and loan defaults. The red line shows the distribution of the ratio of New York 'C' Arabica coffee price at the maturity date divided by the future price for delivery closest to the maturity date at the time the contract was closed. This is the ratio of the realized price, p, over the expected price, $\overline{p}$. During the sample periods international coffee prices have tended to increase, i.e., relatively more contracts have ratios above one. The blue line plots the density of loan defaults conditional on a given price ratio. Consistently with the presence of ex-post moral hazard, defaults are disproportionately concentrated among contracts that have witnessed sharp unanticipated price increases.

A possible objection to Figure 3.6.3 is that managers of coffee washing stations in developing countries might not form expectations based on futures market prices. Figure repeats the exercise proxying unanticipated price increases as the ratio of prices at maturity over price at closing, normalized by the same ratio over the same period a year earlier. The results of the test are qualitatively very robust to this alternative formulation.

Table 3.6.2 provides an econometric investigation of the strategic default test. The econometric investigation allows us to control for a number of factors that might be driving the patterns identified in Figure 3.6.3. Specifically, Table 3.6.2 reports results

from the specification

$$\Phi^{d}_{lst} = a_0 + a_1 p_{lst} + a_2 \overline{p}_{lst} + \beta Z_{ls} + \mu_t + \varepsilon_{lst} \tag{3.8}$$

where Φ^{d}_{lst} is a dummy taking value equal to one if station s defaults on loan l closed at time t.[16] The main regressor of interest is p_{lst}, the realized price at the loan maturity date. To control for expectations about future prices, the specification includes $\overline{p}_{lst}$, the futures price quoted at closing for the maturity date, as a control.[17] Furthermore, we include an extensive vector of station and loan controls Z_{ls} as well as time of closing fixed effects μ_t (ε_{lst} is an error term).[18]

Table 3.6.2 reports results from different specifications. Column 1 presents OLS estimates on the full sample. The estimates show that an unanticipated ten percent increase in the world coffee price over the life of the contract is associated with a 1% increase in the default rate. Column 2 shows the same specification, but presents the probit estimates instead of the linear probability model in Column 1 and obtains qualitatively similar results. Column 3 restricts the sample to the later loans where we have data on both numerical and letter scores. Columns 4 and 5 show the same results with varying levels of controls to analyze the sensitivity of the results to various specifications. The point estimates are extremely robust across a variety of samples and specifications.

Strategic Default: an Event Study Approach

The average upward trend in world coffee prices during the sample period potentially poses a threat to the results in Table 3.6.2 : loans with longer maturity

[16] A loan is in default if it is written-off, restructured or has no payments after ninety days from its maturity dates. Alternative definitions of default yields qualitatively similar results.

[17] Specifications in which the ratio $p_{lst}/\overline{p}_{lst}$ is considered, as in Figure , yields identical results.

[18] Controls in Z_{ls} are country fixed effects, a measure of the history of the relationship between the lender and station, and letter scores fixed effects interacted with all other controls.

might witness larger price increases and also have a higher propensity to default for reasons unrelated to strategic default.[19] On the other hand, the linear specifications in (3.8), might underestimate the importance of strategic default: while world price increases may increase default through ex-post moral hazard, decreases in prices might also increase default simply by limiting borrower's ability to repay the loan.

To overcome these concerns, we implement an 'event study'. The event study takes the largest 25 monthly price increases during the sample period, to examine strategic default. We compare default rates of contracts maturing just before a large price increase (when there is no opportunity for default in response to the shock) with default rates of contracts maturing just after a large price increase (when firms do have an opportunity to respond to the shock).

Table 3.6.3 presents the results of simple t-test comparisons in average default rates in the two samples of contracts. The table investigates specifications that vary with respect to the definition of default as well as with respect to the length of the time window considered for the event study. In all specifications, we find results consistent with strategic default and that are both qualitatively and quantitatively consistent with the OLS estimates in Table 3.6.2. Contracts that mature in the month after a large price increase are 4.8%-6.3% more likely to default. Relative to the price change in the same month the year prior, the average price change is about 10%. So the appropriate interpretation of the t-test is that a price increase of 10% beyond expectations increases default by about 5% on average.

Table 3.6.4 checks the robustness of the result in Table 3.6.3 using an RD specification (see Figure 3.6.5 for the corresponding graph). The RD specification is almost the same methodology as the t-test but it controls for anything else which may

[19] Since we include closing dates fixed effects, the available variation doesn't allow to flexibly control for the length of the loan and, at the same time, identify strategic default out of realized prices at maturity dates. This problem is similar to the well-known fact that it is not possible to flexibly identify cohort, time and age effects (see, e.g., Deaton (1997)).

vary continuously between the before and after groups. Indeed in table 4 the results are very similar to the results in table 3.6.3, ranging from about 3.8% to 9.8% for the same set of price increases. This specification also lends itself naturally to testing robustness to different bandwidths, and varying the bandwidth does little to change the estimates. As a baseline estimate we use the optimal bandwidth as described by Imbens and Kalyanaraman (2012) and test robustness using 75% and 125% of this bandwidth.

Heterogeneity: Relationship's History and Contract Types

The results presented are consistent with ex-post moral hazard being an important determinant of default rates. To further investigate the logic behind strategic defaults, Table 3.6.5 explores heterogeneity in the relationship between unanticipated price increases and defaults along the lines suggested by the ex-post incentive constraints (3.6). Table 3.6.5 also reports results from nonparametric regression discontinuity design specifications, focusing at the discontinuity in the interaction between the distance to a large price increase and the heterogeneity dimension of interest. Each specification controls for both the price increase and the heterogeneity variable separately.

Column 1 focuses on the role played by the history of the relationships between the lender and the borrower, as a proxy for $\delta(\mathbf{V} - \mathbf{U})$. Although the model has left unspecified the determinants of continuation values $\mathbf{V}$ and $\mathbf{U}$, it is plausible that the value of the relationship increases in the age of the relationship between the borrowers and the lender.[20] The value of the relationship is likely to be increasing with the age of the relationship for two reasons. First, there are selection effects: relationships with higher value are, everything else equal, more likely to survive. Second, there might be

[20] See Macchiavello and Morjaria (2013) for a detailed empirical exploration of this idea in the context of Kenya rose exports.

learning effects. During the course of the relationship the lender acquires information about the borrower and, conditional on relationship survival, offers better loan terms. We proxy the age of the relationship in a rather crude way, using a dummy for whether parties have had a previous loan or not. The results confirm the intuition of the incentive compatibility constraint and underscore the importance of informal enforcement: stations are about 7.5% more likely to engage in strategic default when given the opportunity if no prior relationship exists with the lender.

Column 2 focuses on heterogeneity with respect to the type of contract. Although 'differential' contracts do not completely eliminate price risk, the theoretical section highlighted how fixed price contracts are significantly more vulnerable to strategic default. The results confirm that strategic default appears to be significantly more relevant in the sample of loans based on fixed price sale contracts.[21,22]

The Value of Relationships: A Quantitative Exploration of IC Constraints

The evidence reported above is consistent with the logic of the ex-post incentive compatibility constraint (3.6). We now use the incentive compatibility constraint to get a measure of the value of the relationship with the lender and the buyer, $\delta(\mathbf{V} - \mathbf{U})$, for each station in the sample. There are two aspects that are worthy of note. First, the right hand side of the incentive constraint (3.6) depends on the face value of debt, D, the sale contracts q^c and p^c, and the likelihood of finding an alternative buyer, μ. All of these variables are (directly) observable in the data.

[21]The sale contract type is endogenous implying that results could be driven by selection. For example, "worse" borrower are both more likely to default and to have a higher demand for insurance (and end up with a fixed price contract). On the other hand, buyers aware of counterpart risk might be willing to award fixed price contracts only to "good" exporters which are less likely to default. If this is the case, our results are downward biased. Some preliminary evidence suggest the latter hypothesis to be more consistent with the data.

[22]It is worth noting that, due to the difficulties in coding sales contract types, this last result is very preliminary. First, it is performed on a limited sample of loan contracts. Second, measurement error is induced by having coded contracts very conservatively attributing a fixed price rather than a variable price when in doubt. We are in the process of re-coding sale contracts.

Second, in the data we observe both loan repayments as well as defaults. This implies that we can compute lower (upper) bounds to the value of the relationship for repaying (defaulting) borrowers alike.

To take full advantage of the data, we slightly extend the logic of the incentive compatibility constraint (3.6). Upon observing the realization of the world price p, the station has two options: *i*) to repay the loan, or *ii*) to search for a new buyer. In the second case, if the station finds a new buyer, there is default. Otherwise, we assume that the station repays the loan with a three months delay. Furthermore, the data reveal that not all relationships are continued, even conditional on loan repayment. Denote by ρ^R the probability to obtain a loan in the following season conditional on repayment and let $\mathbf{U}^R$ be the net present value of future profits conditional on repayment but not having the loan renewed. With the new formulation, the payoff from repaying the loan is given by

$$\Pi^R(\rho^R) = p^c q^c - D + \delta \left(\rho^R \mathbf{V}^R + (1 - \rho^R) \mathbf{U}^R \right). \tag{3.9}$$

The lender informally punishes default by limiting the probability of future loans after default. Denoting with ρ^L the probability of a loan renewal following a late payment, we can express the payoff associated with searching for an alternative buyer as

$$\Pi^S = \mu \Pi^D + (1 - \mu) \Pi^R \left(\rho^L \right) \tag{3.10}$$

where Π^D is the payoff following default and $\Pi^R(\rho^L)$ is the payoff following a late repayment. Note that the formulation implicitly assumes that the continuation values following a repayment, $\mathbf{V}^R$ and $\mathbf{U}^R$, do not depend on whether the loan was repaid or not (i.e., all punishments come from a lower probability of loan renewal). Denoting with ρ^L the probability of a loan renewal following a default, the payoff associated

with default is given by

$$\Pi^D = pq^c + \delta(\rho^D \mathbf{V}^D + (1 - \rho^D)\mathbf{U}^D). \tag{3.11}$$

Table 3.6.9 reports estimates for the probability of loan renewal conditional on timely repayment, ρ^R, late repayment, ρ^L, and default, ρ^D.[23] The data suggest that $\rho^R \simeq 2/3$, $\rho^L \simeq 1/3$ and $\rho^D = 0$. Moreover, an estimate for μ, the probability of finding a buyer, is given by the proportion of defaults conditional on stations paying late or defaulting. The data give an estimate of $\mu \simeq 1/2$.

We assume $\mathbf{U}^\circ = \mathbf{U}^D$, i.e., the continuation value conditional on the loan not being renewed does not depend on whether the loan was defaulted upon or not.[24] Recall that the value of the loan is a certain proportion, denoted λ, of the value of the contract. As an approximation, we have $D = \lambda \times q^c p^c \times (1 + r)$, where r is the interest rate on the loan.[25]

Substituting the values into the incentive constraints and normalizing the bound by the nominal value of the sale contract, $q^c p^c$, we obtain, after some manipulation, the following representation of the incentive compatibility constraint for a particular loan 'i'

$$\frac{\delta\left(\mathbf{V}^R - \mathbf{U}^R\right)}{q_i^c p_i^c} \geq \left(\frac{p_i}{p_i^c} - (1 - \lambda_i(1 + r_i))\right). \tag{3.12}$$

[23]The table shows decreasing punishments for decreasing severity of default. Clients that have contracts written off or restructured are about 70% less likely to receive a future loan from the lender. Loans that are written off, restructured or no payment is made for 90 days after maturity are 35% less likely to receive a loan in the future from the lender, while loans written off, restructured or no payment is made for only 30 days after maturity are only 26% less likely to receive a future loan from the lender.

[24]This is a strong assumption. Unfortunately, given the nature of our data we do not observe what happens to borrowers to which loans are not renewed. Note, however, that the relationship between $\mathbf{U}^\circ$ and $\mathbf{U}^D$ is ambigous. If there are reputational losses associated with default, $\mathbf{U}^D < \mathbf{U}^\circ$. On the other hand, by defaulting, the borrower obtains higher current period monetary payoff which can help relaxing financial constraints in the next period. In this case, $\mathbf{U}^D > \mathbf{U}^\circ$.

[25]For loans in earlier years we do not observe λ. To maximize sample size and consistency, we proxy λ using the theoretical assignment based on the letter score, i.e., λ takes value equal to 0.4 for score letter B, 0.6 for letter A and 0.7 above that.

Figure 3.6.6 plots the distribution of the right hand side of (3.12) for both repaying and defaulting loans. Two aspects are worth of attention. First, the Figure clearly shows that the estimated (lower bound to the) value of the relationship for repaying borrowers is significantly larger than the estimated (upper bound to the) value of the relationship for defaulting borrowers: informal enforcement is an effective mechanism to deter strategic default. Second, we find the value of informal enforcement associated with the lending arrangement to be very high. On average, it amounts to 54% of the nominal value of the sale contract for which the loan is given on the sample of repaying borrowers. In other words, borrowers forego monetary gains worth a half of the sale contract to preserve a good relationship with the buyer and the lender. Conversely, defaulting borrowers must be given an additional gain worth at least 20% of the sale contract in order to trigger a default.

Are these estimate large or small? To answer this question we need a benchmark. If rents necessary to sustain these relationships are dissipated through ex-ante competition then these estimates can be compared to estimates of the fixed costs of exports. More closely to our set up, Macchiavello and Morjaria (2013) apply a similar methodology to estimate the value of informal relationships with foreign buyers in the context of Kenya rose exports. Macchiavello and Morjaria (2013) quantify the value of the relationship for Kenya rose exporters with foreign buyers to be at least 10% of sales in the relationship. In the next Section we document that borrowers are credit constrained and make relatively large profits from the loans disbursed by the lender. Taken together, these facts suggest that maintaining a good relationship with the lender, not just the buyer, is an important aspect of informal enforcement in this market.

Suppose we agree these are large numbers. What do they mean? Broadly speaking, if we think of commercial relationships as assets, all relationships with positive net

present value should take place. Large estimates suggest that, due to severe contractual frictions, many valuable relationships do not emerge in equilibrium. In the narrower context of our sample, we can try to understand the source of the value from the relationship with buyers and the lender. To do so, we need to look at credit constraints and returns to capital.

3.4.2 Credit Constraints: Evidence from RD Design

The Test for Credit Constraints

Given the evidence above, it would be tempting to infer that borrowers in our sample are likely to be severely credit constrained. First, we have shown evidence of ex-post moral hazard. Ex-post moral hazard limits the borrower's pledgeable income and implies that profitable investment opportunities may not be undertaken for lack of funds. Second, the data show that borrowers derive significant value from preserving good relationships with the lender, suggesting that borrowers find it difficult to replace the lender with alternative sources of credit. To quantitatively assess the importance of credit constraints, however, a more rigorous analysis must nevertheless be developed. First, given relatively low default rates, evidence of ex-post moral hazard is consistent with relatively low levels of credit constraints for few borrowers. Second, the value of the relationship with the lender could stem simply from cheaper loans relative to alternative sources of finance.

Testing for credit constraints, however, poses significant empirical challenges. By definition, a firm is credit constrained if its marginal product of capital is larger than the (marginal) interest rate at which it can borrow, i.e.,

$$MPK_i > (1 + r_i)\,. \tag{3.13}$$

The fundamental challenge is that the marginal product of capital, MPK_i, is not directly observable and hard to estimate econometrically in the absence of exogenous variation in the amount of capital invested. (see, e.g., Keniston (2011)).

In this section we take advantage of data from the internal rating system of our lender to implement a regression discontinuity design on the effects of larger working capital loans. In an important paper, Banerjee and Duflo (2008) develop a test for credit constraints based on a natural experiment that changed the availability of credit to firms of a certain size. The logic of the test is both powerful and elegant. When offered extra credit at the same interest rate, a credit constrained firm will absorb the extra credit to increase investment, input purchase and, ultimately, production. A firm that is not credit constrained might also absorb the additional credit and, potentially, expand production if alternative sources of credit to the firm are more expensive than the newly available one.[26] When this is the case, however, the firm will substitute existing sources of credit at least to a certain extent and completely if production increases. In other words, firms are credit constrained if in response to an exogenous increase in the supply of capital that hold constant the interest rate:

1] **Production Response:** *Purchases of inputs and sales increase* (**PR**),

2] **No Loan Substitution:** *The additional capital is not used to substitute existing, more expensive, sources of credit* (**NLS**).

The test for credit constraints is valid under two additional conditions. First, the decision influenced by the availability of credit must be 'at the margin', i.e., the availability of credit shouldn't affect the decision of whether the firm continues to operate or not. Second, the firm must be able to use the extra loan to pay-down existing loans at no additional costs. These two conditions are hard to verify in

[26] In which case, the firm is said to be rationed by the lender offering cheaper credit but not credit constrained, since $MPK_i = (1 + r_i)$.

general and, ideally, their validity should be assessed on a case by case. A distinctive advantage of our setting is that both are satisfied. First, recall that we focus on working capital loans to purchase a perfectly divisible input (cherries from the farmers). That is, firms can adjust at the margin in response to an increased availability of working capital. Second, working capital loans in our environment are signed before the beginning of the harvest season and mature well within a year, i.e., before the following harvest season. The loans in our portfolio, therefore, are negotiated at a time in which the station can still costlessly adjust on other margins by borrowing less from other suppliers of funds (typically large exporters or domestic financial institutions).

Regression Discontinuity: Design and Loan Outcomes

The credit scores determine the percentage of the contract that is funded, which typically ranges from 40% to 70%. The scores are assigned based on a numerical grade based on an in depth look at the firms financial statements. Numerical grades range from 1-5. Grades below 2.7 receive a grade of C. Firms with a C score do no receive a loan, and do no show up in our sample. However we're told by the lender that there are very few of these, as firms don't apply without a letter of intent from a buyer, which would be difficult to get for poor firms. Most firms receive either a B, which is any score between a 2.7 and 3.35, or an A which is any score between 3.35 and 4.35. Some firms receive a AA, which is a score above 4.35. We use the discontinuities around both the 3.35 and the 4.35 thresholds.

Table 3.6.6 shows the impact of receiving a numerical score just above a threshold on contract terms. We run three specifications. One in which we take the distance to the nearest threshold as the running variable for each loan, and then we also run the distance to each threshold separately. We find an overall difference of about 70% in the pooled sample which may bias upwards the estimate as it compares B loans to AA loans in some cases. However this source of bias is not large, as we get estimates of

about 65% when we look at each threshold individually.[27]

The average loan amount at the pooled threshold is about 300,000 USD. This means that firms just above the pooled threshold are receiving loans of about 405,000 USD while firms just below the threshold are receiving loans of about 195,000 USD for a difference of about 210,000 USD. This is a very large difference in credit access for firms of this size. However, while differences in loan amounts given are very large on either side of the threshold there is no difference in the interest rates given on either side of the threshold. On average interest rates are slightly lower for the more highly scored firms, but the difference is generally only around 1%, and is estimated very imprecisely.

Manipulation of the assignment of observations around the threshold at which the discontinuity is estimated is the main threat to the validity of the regression discontinuity design. Although conversations with the lender suggest that manipulation is unlikely, it is worth conducting more formal tests. Figure 3.6.7 reports the results from the McCrary (2008) test. The test compares the density of observations of the assignment variable around the discontinuity. If there is a discontinuity in the density of the assignment variable at the threshold, then this may suggest that the assignment of some observations might have been manipulated. The Figure clearly shows that no such discontinuity is observed in the data.

In our context, however, there might be incentive to manipulate assignment of observations in either directions: loan officers might want to 'push up' particularly worthy loan applications and 'push down' particularly unworthy ones. Table 3.6.8 takes advantage of the rich nature of our data to explore the relevance of these concerns. The numerical score is based on 30 sub-scores, each ranging between 1 and

[27] The results are fairly consistent with the description of the process as explained to us by the lender. The lender claimed that a 75% difference in loan amount between grades was normal, as they would provide around 40% of the amount needed to fill the contract for a low graded firm and about 70% for a high graded firm.

5. Each sub-score has, therefore, little impact on the overall score. Table 3.6.8 shows that out of the thirty sub-scores, in only one case we can detect a discontinuity in the sub-score at the threshold of interest. The evidence, therefore, appears to be inconsistent with manipulation of the assignment.

Impact of Larger Loans

The evidence above suggests that the regression discontinuity design approximate an ideal experiment in which (essentially) identical loans applications are given different amounts of working capital at the same interest rate. We use this variation in access to credit to test for credit constraints.

Table 3.6.7 reports the results. Column 1 explores whether the additional loan was used to purchase more inputs. Firms indeed used the additional money to buy cherries. Spending on coffee cherries increased by about 40% if we take the average estimate at the 3 different bandwidths. The total money spent on purchases at the threshold is about 528,000 USD, meaning that if 40% of that was the additional amount spent on cherries, the difference in the additional loan amount and the difference in cherry purchases are less than 1% apart from each other (211k versus 210k). Column 2 explores the effect of the larger loans on sales and finds an increase of about 20%. Column 3 considers labour and, consistently with stations operating below capacity, fails to detect a significant impact on the amount of labour used. Taken together, therefore, Columns 1,2 and 3 show that condition (**PR**) in the test for credit constraints is satisfied: firms absorbed the additional loans to increase input purchases and expand production.

Column 4 considers other working capital loans. We find no evidence that firms used the additional loan from our lender to substitute other sources of working capital. In order to compare the effects on other working capital loans with the additional loan, we report results in level. Column 4 shows that the effect on other

loans is not only imprecisely estimated, but also significantly smaller than the 200,000 USD additional loan in all the specifications. Column 4, therefore, shows that condition (**NLS**) in the test for credit constraints is also satisfied: firms did not use the additional loans to substitute other, more expensive, sources of credit. In sum, the evidence suggests that borrowers in the sample are severely credit constrained.[28]

As noted above, there is a constant return to scale technology between amount of cherries purchased by farmers and sales volumes. It is, therefore, interesting to decompose the effects on input purchases and output sales into volumes and prices effects. Column 5 shows that the price of cherries purchased from farmers went up by 20%, implying that the volume of purchases only increased by 20%. The increase in prices paid to farmers is large, but not surprising. At the time of harvest, the aggregate supply of cherries in a given location is inelastic. Stations, which are likely to hold some degree of market power in their local markets, compete with other buyers (mainly traders) to purchase cherries from the farmers. The increase in the price of cherries purchased means that local farmers unambiguously benefit from a station in their area receiving larger loans. This externality is a crucial consideration from a policy perspective, as further discussed below.

Column 6 explores the sale price. There is no reason why the sale price is expected to increase following a larger loan. First, the terms of the sales to the buyer for which the sale contract is used as collateral is either agreed in advance (under 'fixed price' contracts) or at a later date (under 'differential' contracts) at which point the price is determined by market movements. The stations use the additional loans also to

[28]The analysis on station level outcomes can only be performed when information on the financial results for the year in which the loan is disbursed are available. This, essentially, restrict the sample to loans for which the station had a continued relationship with the lender the following year. This introduces sample selection. It is, however, not entirely obvious how this sample selection would bias the results. The sample selects better stations that repaid the loans. These stations might be less credit constrained than defaulting stations, but might be more credit constrained than non-repeating borrowers.

expand sales in the market but then, again, the eventual price of the sale is not directly affected by the size of the loan. Column 6 confirms that the additional loan had no impact on the average sale price for the station.

Returns on the Additional Loans and Value of Relationship with Lender

The additional loans received by firms was largely spent to purchase cherries from farmers. The quantity of cherries purchased only went up by about 20%, because the price of cherries purchased from farmers went up by 20%. Still, a 20% increase in cherry quantity led to a large increase in profits for the stations. The additional 210,000 USD received was translated into an additional 64,000 USD in profit, representing a rate of return of about 32%. This rate of return is significantly higher than the (marginal) interest rate paid on loans.

We can also use these estimate to assess the importance of the relationship with the lender. As a benchmark, imagine that the value of the relationship with the lender is given by net present value of the future (additional) profits the station obtains from the loans. Conditional on repayment, the probability of loan renewal is around 75% and a discount factor of 0.9 (which seems reasonable given interest rates). This gives an effective discount factor equal to 0.675. An increase in loan of approximately 120K $ translates into an increase in profits of approximately. 30K $., a return of approximately. 25% on the loan. Given linear technology, it is relatively safe to extrapolate this returns to the average loan size. Since, on average, a loan is worth 60% of the value of the contract with the buyer, we have that the loan gives profits worth $0.25 \times 0.6 = 0.15$ of the value of the contract, implying an associated discounted value equal to $0.675/(1 - 0.675) \times 0.15 \simeq 0.3$. Recalling that for the average repaying borrower the value of the relationship with the buyer and the seller was approximately 50% of the value of the contract, we have that at least 60% of the value of informal enforcement derives from the relationship with the lender.

3.5 Policy Discussion

Despite the contractual arrangements set-up by our lender, the evidence shows that ex-post moral hazard is an important driver of default and, consequently, credit constraints among coffee washing stations. Strategic default is intimately connected to *i*) imperfect enforcement of international trade contracts, and *ii*) (unanticipated) fluctuations in the international price of coffee. These forces are, however, by no means specific to the environment under consideration. Waves of defaults in the international trade of commodities are often triggered by swinging international prices. For example, an unprecedented wave of broken contracts has upended the cotton marketplace following volatile price swings: the number of arbitration cases handled by the International Cotton Agreement has soared during the recent cotton price boom from an average of seventy per year to more than two hundred cases.[29] Most of the disputes end up with contracts being renegotiated. Even after winning arbitration cases, however, companies struggle to enforce awards in foreign courts especially in developing countries as it is difficult to prevent blacklisted defaulters from continuing to do business under new names or through intermediary trading houses.

Strategic default is intimately connected to the use of fixed price contracts. This raises the question as of why foreign importers agree to enter fixed price contracts with exporters at times of high price volatility. The answer most likely lies in asymmetric access to insurance and hedging markets between the contractual parties. With fixed price contracts, buyers guarantees availability of coffee and typically insure themselves through hedging on features markets. Sellers eliminate both price and quantity risk. Fixed price contracts, however, expose parties to counterpart risk:

[29] For a recent discussion see, e.g., http://online.wsj.com/article/SB10000872396390444772804577623532167565646.html (accessed on-line November 12th 2012).

buyers renege when prices falls and sellers renege when prices raise. A natural solution would be to try to extend access to hedging markets to exporters from developing countries. This is, however, complicated by the difficulties in aggregating relatively small producers as well as by the large collateral requirements necessary to undertake hedging transactions. The evidence in the paper suggests that strengthening relationships with buyers can facilitate access to working capital finance, i.e., there might be a role for export promotion and association black-listing defaulters to be played.[30]

Finally, we have documented contractual externalities along the chain: farmers benefit from larger loans given to the stations in the form of higher prices. Since stations cannot pledge farmers' surplus to obtain loans, not just the station, but the chain as a whole is credit constrained. These contractual externalities can be mitigated by fostering integration along the chain. Integration can be achieved by private processors integrating (backward) into coffee growing by acquiring an estate. In many context, however, this option is likely to be limited by the same type of credit constraints we have documented as well as by other constraints working against consolidation in land markets. Cooperatives, in which farmers own processing units, could in principle provide an alternative form of (forward) integration.

3.6 Conclusion

In sum, the study provides evidence on the sources (ex-post moral hazard) and consequences (credit constraints along the supply chain) of credit market

[30]Commodity price stabilization has featured prominently in development debates, though mostly from a macro point of view. Keynes (1943), Prebisch (1950) and Singer (1950) have been among the most influential supporters of unilateral and multilateral stabilization programs for commodity prices. Bauer and Parish (1952), Friedman (1954), McKinnon (1967) and Stiglitz and Newbury (1981) argued against price stabilization mechanisms and in favour of market-based solutions, which have been followed since the mid '80s in most countries.

imperfections among relatively large firms in developing countries. As discussed above, the contractual practices adopted by our lender already mitigate sources of credit market imperfections, including those for which we find direct evidence. Therefore, our study identifies a lower bound to the cost of credit market imperfections.

Moreover, we tie the presence of these imperfections to underlying features of the environment, particularly the lack of access to hedging instruments. Exploring in greater details the determinants of contractual choices in this environment is left for future research.

Table 3.6.1: Descriptive Statistics

Variable	Mean	St. Dev.	Observations
		Panel A: Station-Years	
Total Assets	1,547,667	2,471,357	657
Total Liabilities	1,009,020	1,848,895	636
Net Equity	572,096	834,719	658
Financial Debt	811,482	1,496,571	470
Working Capital	183,830	436,375	653
Total Income	2,806,948	5,177,489	648
Cost of Goods Sold	2,441,362	4,688,685	642
Net Profit	49,110	143,199	651
Permanent Employees	36.7	169.9	413
Seasonal Employees	89.4	291.7	412
		Panel B: Loans	
Loan Amount	344,697	390,589	753
Interest Rate	0.098	0.011	753
Previous Loan with Lender	0.29	0.45	753
Numerical Score	3.60	0.24	288
Length of Loan (Days)	300	302	753
Write-Off	0.027	0.161	753
Write-Off of Restructured	0.029	0.169	753
Write-Off, Restructured or 30 days without payment	0.061	0.24	753
Write-Off, Restructured or 60 days without payment	0.05	0.219	753
Write-Off, Restructured or 90 days without payment	0.048	0.214	753
World Price at Closing	346.45	123.63	753
World Price at Maturity	378.85	133.65	753
Price Change Over Life of Contract	1.137	0.262	753

Notes: The sample of station years is a constructed panel based on financial statements for the 3 years prior to a loan being given. For firms with loans in multiple years, the panel includes financials for both before and after loans were given. The sample of contracts is all coffee contracts from our lender. We have a letter score for all contracts, but a numerical score for only a subset of contracts, as the numerical score system was introduced by the lender partway through the sample. The sample also only includes contracts that were closed at the time of receiving the data. Open loans were omitted as they did not have the same opportunity for default.

Table 3.6.2: International Prices and Default

	Dependant Variable: Write-off, restructured or no payment after 90 days late				
	(1)	(2)	(3)	(4)	(5)
Price Ratio	0.114***	1.459**	0.429***	0.0794**	0.111***
	(0.0406)	(0.618)	(0.0811)	(0.0376)	(0.0410)
Model	OLS	Probit	OLS	OLS	OLS
Sample	Full	Full	Numerical Score Only	Full	Full
Futures Price (maturity) at Closing Date	Y	Y	Y	N	Y
Letter Score Fixed Effects	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y
Closing Month Fixed Effects	Y	Y	Y	Y	Y
Previous Relationship	Y	Y	Y	N	N
Number of Loans to Client Fixed Effects	Y	Y	Y	N	N
Observations	699	588	289	704	699
R-squared	0.280	N/A	0.351	0.273	0.279

Notes: ***, **, * denote statistical significance at the 1%, 5% and 10% level respectively.
Description: The table reports the estimated difference in mean rates of default when the world price of coffee doubles during the life of the contract. The price ratio here is defined as the price at maturity over the price at closing. Robust standard errors clustered by country are reported in parentheses.

Table 3.6.3: Out of Season Price Increases and Default Robustness

	(1) Write-Off, Restructured no payment after 30 days	(2) Write-Off, Restructured no payment after 60 days	(3) Write-Off, Restructured no payment after 90 days
t-test: 2 Month Window	0.0636**	0.0559**	0.0486**
	(0.0259)	(0.0237)	(0.0228)
Observations	419	419	419
t-test: 3 Month Window	0.0458**	0.0403**	0.0343*
	(0.0214)	(0.0194)	(0.0187)
Observations	552	552	552
t-test: 4 Month Window	0.0497**	0.0419**	0.0366**
	(.0199)	(.0179)	(.0174)
Observations	616	616	616

Notes: ***, **, * denote statistical significance at the 1%, 5% and 10% level respectively. The number of months from one of the top 25 monthly price increases is the grouping variable, and we restrict the sample to contracts 1 month before and one month after to be sure results above are driven by contracts around the threshold. For contracts that end in the month of an event, we assign the contract to the 'before' group if the contract matures in the first half of the month and the 'after' group if the contract matures in the second half of the month.
Description: Estimates show that out-of season price increases have a positive impact on default through the strategic default mechanism. When the price of coffee increases but the price of inputs does not, strategic default is most likely. The results are almost identical to the results using the discontinuity methodology.

Table 3.6.4: International Prices and Default - Robustness

	(1) Write-Off	(2) Write or Restructured	(3) Write-Off, Restructured or no pmt after 30 days	(4) Write-Off, Restructured or no pmt after 90 days
Optimal Bandwidth	0.0385*	0.0448*	0.0986**	0.0500***
	(0.0223)	(0.0231)	(0.0485)	(0.0173)
75% Optimal Bandwidth	0.0187*	0.0250**	0.0540**	0.0500***
	(0.0108)	(0.0124)	(0.0249)	(0.0173)
125% Optimal Bandwidth	0.0395*	0.0462**	0.1000**	0.0919***
	(0.0221)	(0.0229)	(0.0483)	(0.0321)
Observations	755	755	755	755

Notes: ***, **, * denote statistical significance at the 1%, 5% and 10% level respectively. The estimates are calculated using a regression discontinuity design using the kernel density method. A triangle kernel was used and the optimal bandwidth was calculated as in Imbens and Kalyanaraman (2012). The number of months from one of the top 25 monthly price increases is the running variable.
Description: The table reports the estimated difference in mean rates of default when the world price of coffee increases immediately before the contract matures as opposed to immediately after. It shows that in-season world price increases do not have a significant impact on default, and if anything reduce default by reducing credit constraints. Out of season price increases have a positive impact on default through the strategic default mechanism. When the price of coffee increases but the price of inputs does not, strategic default is most likely.

Table 3.6.5: International Prices and Default, Heterogeneity

Dependent Variable: Write-Off, Restructured or No payment for 90 Days		
	(1) Mature after P jump x (No) relationship history	(2) Mature after P jump x Fixed price contract
Optimal Threshold	0.0754**	0.0516***
	(0.0371)	(0.0179)
75% Optimal Threshold	0.0754**	0.0516***
	(0.0371)	(0.0179)
125% Optimal Threshold	0.0754**	0.0944***
	(0.0371)	(0.0329)
Observations	756	756

Notes: ***, **, * denote statistical significance at the 1%, 5% and 10% level respectively. Due to complications with the fixed price coding, we only know that a subset of firms do not have fixed price contracts. We define a fixed price contract as a contract where a percentage of the contract is not tied to the world coffee price. The estimates are calculated using a regression discontinuity design using the kernel density method. A triangle kernel was used and the optimal bandwidth was calculated as in Imbens and Kalyanaraman (2012). Each specification controls individually for each element of the interaction.
Description: This table shows heterogeneity in strategic default, showing that default is driven by firms that got smaller loans, firms without a prior history with the lender and firms with fixed prices.

Table 3.6.6: Regression Discontinuity Results, Loan Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	log(Loan Amount)			log(Interest Rate)		
	Pooled	B to A	A to AA	Pooled	B to A	A to AA
Optimal Bandwidth	0.713**	0.675**	0.659*	-0.0140	-0.00610	-0.0147
	(0.287)	(0.303)	(0.364)	(0.0167)	(0.0240)	(0.0142)
75% Optimal Bandwidth	0.764**	0.770**	0.751*	-0.0153	0.0128	-0.0190
	(0.324)	(0.365)	(0.394)	(0.0184)	(0.0257)	(0.0162)
125% Optimal Bandwidth	0.616**	0.623**	0.563	-0.00990	-0.0135	-0.0144
	(0.265)	(0.284)	(0.347)	(0.0158)	(0.0223)	(0.0136)
Observations	197	197	197	189	189	191

Notes: ***, **, * denote statistical significance at the 1%, 5% and 10% level respectively.The estimates are calculated using a regression discontinuity design using the kernel density method. A triangle kernel was used and the optimal bandwidth was calculated as in Imbens and Kalyanaraman (2012). The distance in numerical score points to the threshold is the running variable in each specification. Controls include the amount requested, and renewals.
Description: The table shows that getting a score just above the threshold results in a 65% higher loan at each threshold. This is consistent with what was told to us by the lender. The lender typically lends between 40%-70% of the working capital deficit, depending on the letter score and loan size. If the 40% - 70% difference was a hard rule this would result in an estimate of 0.75. While there is a very sharp increase in the loan amount at the threshold, there is no difference in the interest rate given to the client.

Table 3.6.7: Regression Discontinuity Results, Firm Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	Spent/Earned				Prices	
	log(Purchases)	Sales	log(Labour)	Other Loans	log(Purch. P)	log(Sales P)
Optimal Bandwidth	0.477*	1,587,345**	0.218	21.86	0.221**	0.254
	(0.263)	(730,861)	(0.441)	(280.3)	(0.102)	(0.227)
75% Optimal Bandwidth	0.300*	1,872,649**	0.218	-68.90	0.264**	0.420
	(0.512)	(818,399)	(0.509)	(312.0)	(0.115)	(0.295)
125% Optimal Bandwidth	0.429*	1,312,218*	0.219	67.65	0.212**	0.103
	(0.256)	(681,457)	(0.415)	(267.2)	(0.0974)	(0.209)
Observations	167	189	180	112	189	189

Notes: ***, **, * denote statistical significance at the 1%, 5% and 10% level respectively.The estimates are calculated using a regression discontinuity design using the kernel density method. A triangle kernel was used and the optimal bandwidth was calculated as in Imbens and Kalyanaraman (2012). The distance in numerical score points to the threshold is the running variable in each specification. In some cases, due to many missing values, similar variables are used to predict missing observations. For example, cost of goods sold is sometimes used to predict spending on cherries, when observations are missing. In these cases the variables used to predict the missing observations (e.g. cost of goods sold) are included as controls.
Description: The table shows that firms are credit constrained. Getting a score just above the threshold results in a 40% more money spent purchases, almost 20% of which is from increased quantity purchased. The additional purchases in cherries results in almost 65,000 higher profit, strong evidence of credit constraints. The additional money helps farmers, as prices for cherries increase by over 20%.

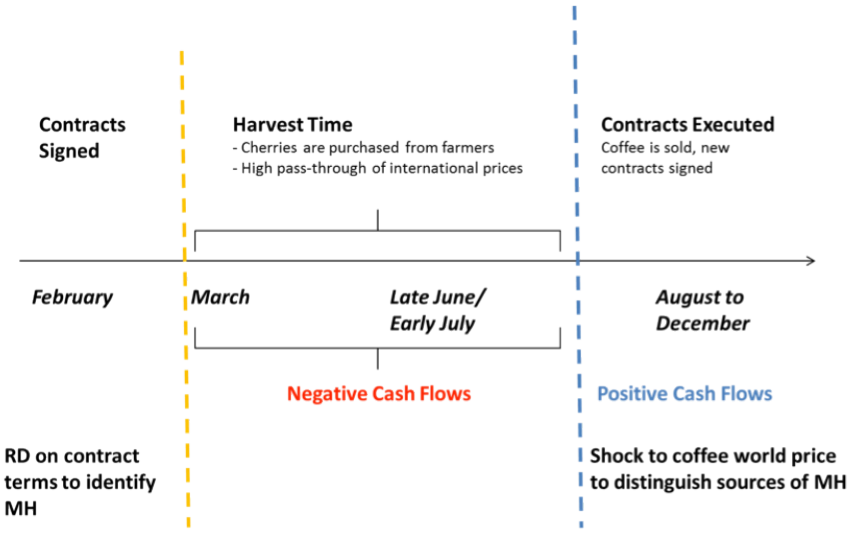
Tables

Table 3.6.8: Regression Discontinuity Robustness: Test for Manipulation of Sub-scores

Running Variable: Distance to Threshold (Overall Score)			
Dependent Variable	Estimate	Standard Error	Observations
Entity Score	0.108	(0.109)	315
Accounting Quality	0.221	(0.226)	315
Planning Systems	0.250	(0.156)	315
Liquidity Risk	-0.0561	(0.206)	315
Leverage	0.156	(0.178)	315
Profitability	0.0934	(0.189)	315
Credit History (RC)	0.155	(0.203)	312
Asset Quality	0.205	(0.168)	303
Product Score	0.0407	(0.0960)	315
Processing	0.156	(0.131)	315
Supply Security	-0.0630	(0.103)	315
Management Score	0.0176	(0.114)	315
General Manager	-0.0649	(0.168)	315
Finance Accounting	0.0795	(0.190)	315
Internal Controls	0.156	(0.169)	314
Marketing Sales	-0.132	(0.162)	315
Staff Retention	0.142	(0.170)	303
Report Quality	0.00691	(0.142)	314
Report Punctuality	0.00318	(0.151)	302
Email Promptness	0.130	(0.168)	314
Email Quality	0.0682	(0.158)	302
Buyer Score	0.116	(0.0901)	315
Buyer Quality	0.158	(0.119)	315
Buyer Relationship	0.170	(0.165)	315
Buyer Mix	0.607**	(0.288)	315
Type of Contract	0.114	(0.160)	300
Context Score	-0.0328	(0.0473)	315
Weather	-0.0422	(0.146)	315
Country Stability	0.0621	(0.128)	314
Sales Price Volatility	0.0897	(0.222)	300

Notes: ***, **, * denote statistical significance at the 1%, 5% and 10% level respectively. This table shows the placebo for the manipulation of the sub-scores which make-up the numerical score that is used in the RD estimates. Only one out thirty sub-scores shows any difference on either side of the overall score threshold, but at least one of thirty would is expected as a false positive. We interpret this as evidence supporting the assumption that there was no manipulation or sorting of scores in order to give preferred clients better contractual terms.

Figure 3.6.1: Timing of Events (Rwanda Example)

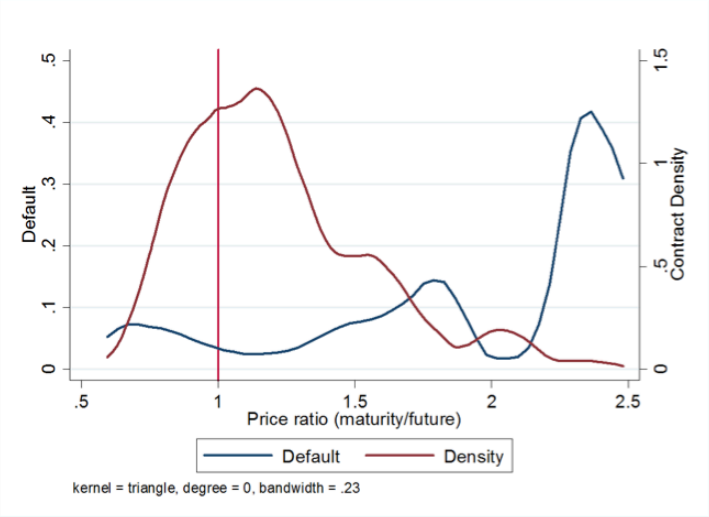


The Figure depicts the typical timing of events in the case of Rwandan contracts.

Figure 3.6.2: Seasonal Distribution of Contract Timing

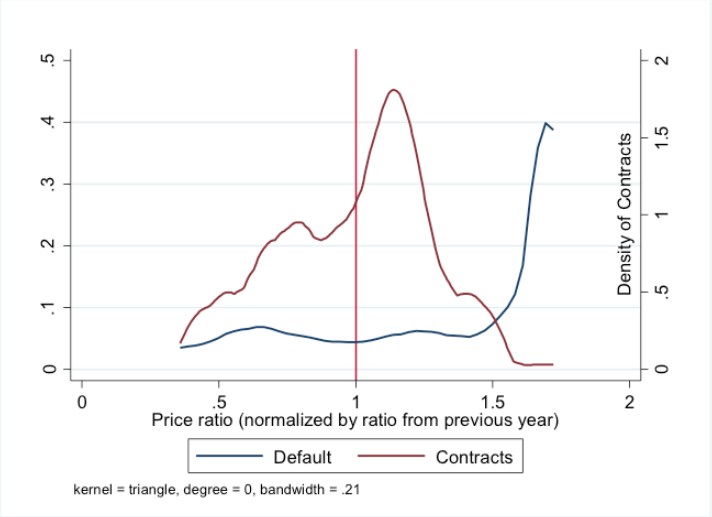
The Figure shows seasonality patterns in the closing and maturity dates of loan contracts in the sample. The closing date (blue lines) refers to the month in which the loan contract is signed. The maturity date (red line) refers to the date at which the loan is supposed to be repaid. The Figure illustrates the bi-modal distribution in the distributions of both closing and maturity dates. The two picks in each distribution are driven by asynchronous coffee harvest seasons across countries and altitude ranges. Contracts tend to be closed just ahead of, or in the early phases, of the harvest season. For example, most contracts in Peru (which represents 34% of the loans in the sample) are closed in May – June, in Nicaragua (which accounts for 11% of the loans in the sample) most contracts are closed in October – December, in Rwanda (which accounts for 8% of the loans in the sample) most contracts are closed in March – April.

Figure 3.6.3: Unanticipated Price Increases and Defaults (Part I)



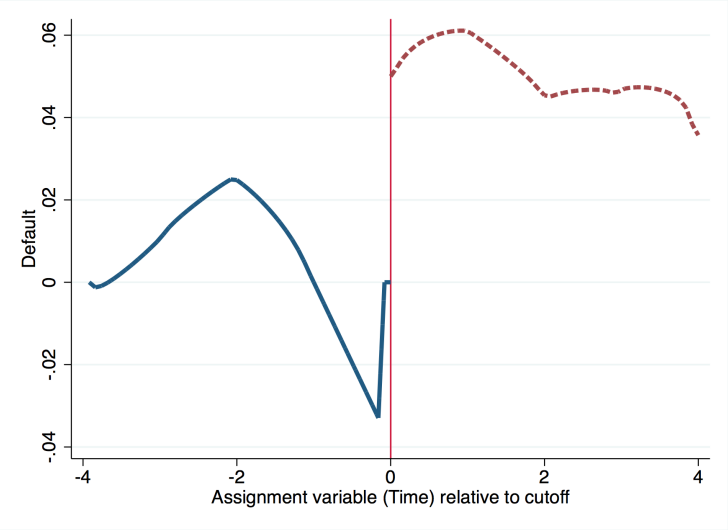
The Figure shows the relationship between unanticipated increases in international coffee prices and loan defaults. The red line shows the distribution of the ratio of New York C Arabica coffee price at the maturity date divided by the future price for delivery closest to the maturity date at the time the contract was closed. During the sample periods international coffee prices have tended to increase, i.e., relatively more contracts have ratios above one. The blue line plots the density of loan defaults conditional on a given price ratio. Defaults, measured as [insert details] are disproportionately concentrated among contracts that have witnessed sharp unanticipated price increases.

Figure 3.6.4: Unanticipated Price Increases and Defaults (Part II)



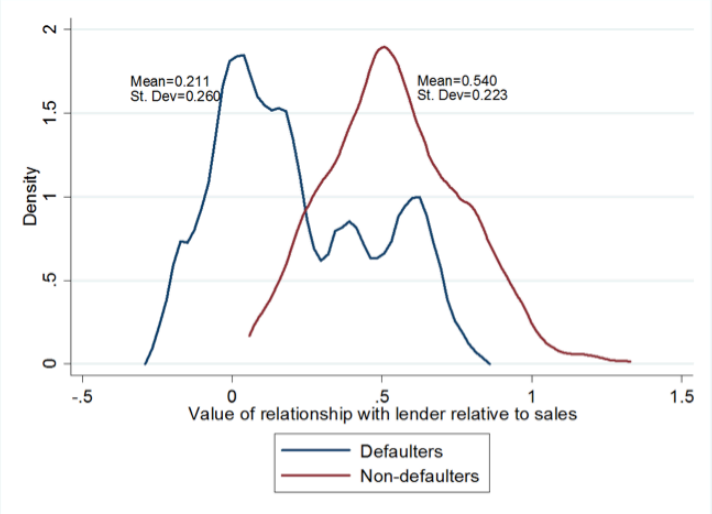
The Figure shows the relationship between unanticipated increases in international coffee prices and loan defaults. The red line shows the distribution of the ratio of New York C Arabica coffee price at maturity date divided by the same price at closing date, normalized by the same ratio for the previous year. During the sample periods international coffee prices have tended to increase, i.e., relatively more contracts have ratios above one. The blue line plots the density of loan defaults conditional on a given price ratio. Defaults, measured as [insert details] are disproportionately concentrated among contracts that have witnessed sharp unanticipated price increases.

Figure 3.6.5: Regression Discontinuity Graph - Price Increase Event Study



The figure shows the increase in default for contracts that mature just before rather than just after a large price increase. Default is measured as any contract written-off, restructured or for which no payment was received for 90 days after maturity. A window of 4 months before and after the price increase is shown in the figure. The figure is the graphical version of the estimates in table 4, and shows that the effect is not driven by a large decline before the threshold, or other odd functional form issues. The slight spike before the threshold is expected due to the imperfect coding of contracts that mature in the same month as a large price increase, and this effect is expected to downward bias the estimates, as demonstrated by the graph. A triangle kernel was used and the optimal bandwidth was calculated as in Imbens and Kalyanaraman (2012). The number of months from one of the top 25 monthly price increases is the running variable.

Figure 3.6.6: The Value of Informal Enforcement for Defaulters and Non-Defaulters



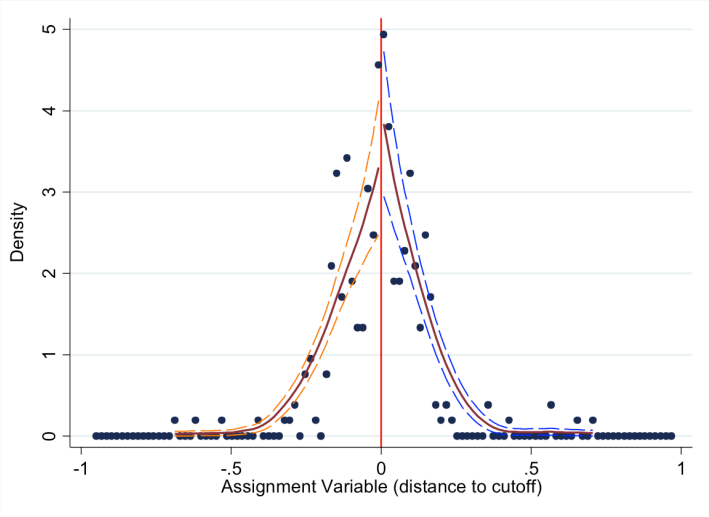
The figure shows the relationship between relationship value (relative to sales) and the distribution of default. The red line shows the relationship values of firms that did not default, while the blue line shows the relationship values of firms that did default. Firms that default have lower relationship values throughout the distribution, suggesting that informal enforcement is an effective mechanism in managing default. Relationship value is calculated as $(P_{market} - P_{expected})/P_{expected} + factor$ (see text for explanation).

Table 3.6.9: Informal Punishment for Default by the Lender

	(1)	(2)	(3)	(4)
	Dependent Variable: Future Contracts From Lender			
Write-off	-0.698***			
	(0.0696)			
Write-off or restructured		-0.702***		
		(0.0690)		
Write-off, restructured or no payments for 90 days			-0.352***	
			(0.122)	
Write-off, restructured or no payments for 30 days				-0.265**
				(0.103)
World Price and Futures	Y	Y	Y	Y
Letter Score Fixed Effects	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y
Closing Month Fixed Effects	Y	Y	Y	Y
New Client Dummy	Y	Y	Y	Y
Number of Loans to Client Fixed Effects	Y	Y	Y	Y
Observations	702	702	702	702
R-squared	0.661	0.663	0.638	0.632

Notes:*** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered by Country. The table shows that stations are punished for defaulting on contracts. If a station has a contract written off, they are about 70% less likely to receive a loan from the lender in the future.

Figure 3.6.7: Regression Discontinuity Graph - Sorting Around the Threshold



The figure shows that he lender did not manipulate scores around the threshold to give larger loans to preferred clients.

4

Culture and Contracts: The Historical Legacy of Forced Labour

4.1 Introduction

There is widespread agreement that colonial extractive institutions play a role in explaining current economic development. More contentious has been explaining why this association exists. In this study we focus on how colonial extractive institutions can influence development through a cultural channel, over and above the persistence of these institutions (Acemoglu et al. (2001)) or their effect on human capital (Glaeser et al. (2004)). Despite being prominently discussed as a potentially important mechanism (Nunn (2012)), there is currently little evidence that colonial institutions continue to influence economic outcomes through culture. Although there is good reason to believe that this mechanism is important, as historical events have been shown to still shape current attitudes (Nunn and Wantchekon (2012))[1]. This paper provides a concrete example of how colonial extractive institutions can

[1]For a link between economics and culture see Knack and Keefer (1997), Guiso et al. (2004), Algan and Cahuc (2010), Hjort (2011). For a review of the literature on trust and economic activity, see Alesina and LaFerrara (2005).

impact economic development through culture by examining the lasting economic impact of one specific colonial institution, through one dimension of culture.

We study the colonial era introduction of forced labour in Rwanda and Burundi, and the impact that it had on interethnic attitudes between the Hutu-Tutsi. In the post-colonial era the Hutu and Tutsi have been sharply divided, with Hutu extremists killing 1,000,000 Tutsi and Tutsi sympathizers in the 1994 Rwandan genocide. These tensions are thought to have been exacerbated by Belgian colonial policy in the coffee sector. In particular, the Belgians allowed the Tutsi chiefs to recruit Hutu coffee farmers into forced labour. We use this policy to investigate the origins of ethnic tensions, and quantify their importance for maintaining successful agreements. We find that a family history of forced labour worsens interethnic attitudes, and increases the reliance on within ethnicity economic relationships, which leads to worse partner matches and increases contractual default.

Forced labour was introduced after Belgium assumed control of Rwanda and Burundi and was related to coffee production. One of Belgium's first colonial policies was to encourage the production of coffee with subsidies so that they could integrate the region into the monetary economy and tax the profits from coffee[2]. After these initial programs were unsuccessful, the Belgians introduced coffee quotas in 1931, under which, each Chief was responsible for the maintenance of 1,000 healthy coffee trees. Maintaining these trees was a large burden on the Chiefs in some regions, so in these regions the Belgians allowed the use of Hutu forced labour. Each Chief was Tutsi, and only Hutu farmers were eligible for the program[3]. This is expected to have contributed to interethnic tensions:

[2]Prior to this much of the economy relied on the trade of cattle which was not easily taxable by colonists

[3]This was rationalized by arguing that the policy was less harmful to Hutu communities since traditionally taxation could be paid for with labour in these communities, but the same traditional institution did not exist in Tutsi communities. Forced labour was deemed more culturally acceptable to Hutu than to Tutsi.

> "The looting and the forced labour continued unabated and, even if the massacres and amputations stopped, the punishments imposed in their place were almost equally vicious...While 'kiboko' is Kiswahili for hippopotamus, Belgians had adopted 'ikiboko' as the name for a strip of hippo hide that was used as a lash...The humiliating part came with having to bare the bottom, while lying on the ground, face down, which was calculated to inflict maximum pain. As for the divisive part, the colonialist administered those eight lashes on the chief, out of sight of his citizens, and then directed the chief to do the same on the offenders...That way, the [Hutu] citizens blamed their [Tutsi] chief, not the colonial master." - Butamire (2012)

To evaluate the impact of colonial era forced labour on economic relationships I bring together data from several sources: (1) a field survey on contracts from Hutu and Tutsi farmers. Contracts in the data are inter-household crop insurance, where transfers are made between households producing different crops when one of the crops experiences a bad harvest[4]. I collect information on the number of defaults and agreements, the value of the agreements, and the reasons for default. (2) Trust game data between people both within and between ethnicities, and across 143 villages[5]. Due to the sensitivity of the issue, data on interethnic trust[6] is rarely available where tensions are highest[7]. The trust game allows me to construct a measure of interethnic tensions without making ethnicity salient[8]. (3) Constructed data on historical forced

[4]This type of agreement is also discussed in Kinnan, 2008

[5]see Berg et al. (1995), Barr (2003), Glaeser et al. (2000) for more on the trust game, and Barr (2003), Fehr and Goette (2005) for the trust game implemented in the field.

[6]The attitudinal change measured could be distrust, resentment, indignation, anger, retribution, vengeance, etc. I remain agnostic about the specific change in attitude.

[7]Yet these are the regions where observing the economic implications of tensions is most important

[8]The trust game has been used to measure interethnic attitudes before (Fershtman and Gneezy (2001))

labour from historical reports and archival sources. While local forced labour is very difficult to observe, crop profitability allows us to back out village level exposure, which was directly associated with the ability of the Chiefs to meet coffee quotas. This measure is constructed using archival data on national crop prices, and GIS estimates of crop suitability. The final dataset consists of over 600 individuals, and I observe historical family location from one of 332 forced-labour era villages from the (unified) colonial state of RuandaUrundi.

My empirical approach uses a differences-in-differences and regression kink design to investigate whether (a) forced labour on coffee farms impacted Hutu resentment towards Tutsi, and (b) this Hutu-Tutsi resentment influences economic relationships. First, I show that forced labour influenced Hutu resentment of Tutsi by comparing the trust game offers from Hutu to Tutsi, between two Hutu living in the same village, but with different forced labour family histories. Hutu whose grandparents parents worked on coffee farms in forced labour villages make significantly lower offers to Tutsi in the trust game than other Hutu. They don't, however, make lower offers to other Hutu, and Tutsi do not make lower return offers in these regions. This shows that historical interethnic mistrust was passed from grandparent to parent to child, throwing light on the theoretical mechanism advanced by Tabelini (2008) about the transmission of cultural traits.

I proceed by documenting that the increased interethnic resentment causes a greater economic reliance on the ethnic community. I show that Hutu with a family history of mistreatment are 10% more likely to pass up on potentially profitable opportunities with Tutsi business partners. This increased ethnic network reliance has economic implications, but those implications are theoretically ambiguous. On the one hand, doing business within a closed community improves information,

coordination and enforcement imperfections[9]. On the other hand though, the Hutu were historically more agrarian and the Tutsi were more pastoral (Destexhe (1995)), so restricting these agreements within networks could reduce inter-household crop insurability, and increase default.

Our data on economic agreements resolves this ambiguity. Hutu with a history of mistreatment experience 28% more contractual default than Hutu without a family forced labour history in inter-household crop insurance agreements. Tutsi, who were not eligible for forced labour, do not experience more default if their families were from a forced labour village. This is consistent with the idea that restricting economic activity within communities constrains the ability to find a good match. People that partner with less well matched individuals experience more contractual default.

Following this logic, it should be true that the increase in defaults was the result of a worse partner match rather than dishonesty or low effort on behalf of the partner. Data was collected on the perceived reasons of default, and analysis of this data reinforces the idea that default was due to worse partner matching. Hutu from mistreated families were 45% more likely to experience contractual default due to the ability of their partner to make an insurance transfer, but no more likely to experience default due to the effort of their partner. Tutsi from forced labour villages were no more likely to experience an increase in default due to either their partners ability or effort.

Finally, I show the implications of this mechanism on income. Those whose grandparents were exposed to forced labour on coffee farms earn 15% less income than other Hutu. This is consistent with an income loss estimate that relies only on the default rate and value of defaulted contracts. This data reveals that if all of the

[9]We know that culture is especially important when information is incomplete - it has be defined as rules of thumb that evolve to avoid costly information acquisition (Boyd and Richardson (1985); Gilboa and Schmeidler (1995); Gigerenzer and Goldstein (1996); Boyd and Richardson (2005); Gigerenzer and Goldstein (2007). Also, see Karlan et al. (2009) and Karlan (2007)

decrease in income came from an increase in defaults, we should expect a 12% reduction in income.

This helps to resolve one identification concern: that the forced labour caused a direct reduction in income, and low income, not trust, impacts the sustainability of economic relationships. I interpret the similarity of the two income estimates as evidence that very little of the direct effect of forced labour on income is unaccounted for. This seems reasonable as in each specification the direct effect of income on forced labour is instrumented for, using a predicted income variable based on grandparent land characteristics. This variable is highly correlated with current income so it is likely capturing the bulk of the direct historical income effect.

A second identification concern may be that trust develops to overcome imperfections in the contracting environment (McMillan and Woodruff (1999); Macchiavello and Morjaria (2013)). This is potentially true in Rwanda and Burundi, however the empirical specifications control for this, so it is not an alternative interpretation of these results. Every specification includes current village fixed effects, which accounts for differences in the current contracting environment.

More challenging is accounting for the effect of the historical contracting environment. It may be a concern that grandparent contractual environment could have been related to altitude through institutions or historical shocks (e.g. Nunn and Puga (2012)), which is also correlated with coffee profitability and therefore forced labour. To resolve this concern I test both a differences-in-differences specification and a regression kink specification. The regression kink design relies on the fact that wherever coffee was a primary crop, forced labour was banned by the Belgians. And when it was secondary or third crop, forced labour was allowed, but only enough was allowed to close the gap between the current production and the quotas. This means that there was a sharp change in the slope of forced labour with respect to coffee

profitability around the threshold at which coffee became the most profitable crop. This strategy identifies the effect of forced labour by comparing people from villages *just* on either side of the threshold. That is, it compares people from historical villages with nearly identical land characteristics. Because of this feature, the regression kink strategy is able to control for the effect of historical contracting environment. The difference-in-differences estimates and the regression kink estimates are very similar.

Other concerns may also exist. For example, the effect of the genocide could reduce interethnic trust and confound estimates. Genocide era village fixed effects can account for this effect, but to as an additional check, I run the main results for the Burundi-only sample where there was no genocide, and the results are nearly identical. Yet another concern may be migration. On one hand migration helps identification, because it allows for the separation of current contractual environment from historical events using current village fixed effects. Because of the fixed effects, identification relies on a comparison between migrants. However *differential* migration could be problematic. For example, there may have been more migration among mistreated Hutu three generations ago, and recent migrants may be treated differently than third generation migrants. Differential historical migration seems unlikely, since fleeing forced labour was very difficult and was brutally punished (Gourevitch (1998)). However, the collection of extensive family migration data allows this mechanism to be explicitly tested. I find no differences in migration rates at any generational level among Hutu since the colonial era, so migration is not a threat to identification.

The remainder of the paper proceeds as follows. In the next section the historical setting surrounding forced labour in Rwanda and Burundi is described. In section 3 I explain the data that I collected to analyze the impact of forced labour on interethnic trust and economic relationships. Section 4 explains the empirical strategies pursued,

and how any remaining identification concerns are dealt with. Section 5 outlines the main results and discusses the robustness and falsification tests. Finally, section 6 concludes.

4.2 Historical Background

Prior to German colonial reign (1897-1916) the Hutu and Tutsi had little conflict and lived in segregated communities (Nyirubugara (2013))[10]. Communities relied on prominent local lineages for public goods, and non-monetary goods were voluntarily exchanged for protection and representation (Newbury (1988)). The lineage system traditionally served in lieu of a functioning government (Maquet (1961)) and cattle played a prominent role, serving as the primary medium of exchange (Destexhe (1995)). There were three types of traditional chief-farmer relationships (clientship), and clientship was ubiquitous[11]. I focus on one type - the payment of taxes using labour. This was exclusive to the Hutu, who did not historically own cattle (Newbury (1988))[12].

Traditional clientship transformed under the first RuandaUrundian king

[10]Two factors are responsible for the change in Hutu - Tutsi relations. The first is a rinderpest based famine in the early 20th century, which caused migration, increasing interactions, and tensions over good land. This raised tensions in general, but when a Tutsi community would migrate to Hutu community or vice-versa, they were more likely to be seen as outsiders. This effect interacted with the second effect: the beginning of the Rwabugiri era.

[11]The first type was *Umuheto*, whereby a client would purchase protection in exchange for a cow. Protection was exchanged in each of the clientship types. It involved physical protection, protection of property and legal protection from a patron associated with a prominent lineage. *Umuheto* seems to have been more common in regions of low population density. The second type was *Ubuhake*, which involved the loan of pasture land for the cattle of a prominent lineage in exchange for protection. The patrons cattle would be taken care of by the client, and all financial gains would go to the patron while all land/labour costs would be bourn by the client. Finally, for people with no land suitable for cattle or any cattle to trade for protection, *Ubureetwa*, the third type of clientship was available (Newbury (1988)).

[12]Cattle was culturally important in RwandaUrundi as a status of wealth, and nearly all Tutsi owned cattle. Hutu were traditionally agriculturalists, but some prominent Hutu did own cattle. The cattle divide was so prominent between Hutu and Tutsi that many sources claim that a Hutu could claim Tutsi status if (s)he wanted once (s)he had acquired enough cows (e.g. Destexhe (1995))

Rwabugiri (r. 1863 – 1895)[13]. Rwabugiri created the first army and appointed district chiefs to offer many of the services traditionally offered by lineages (Bourgeois (1957)). This increased economic burdens on lineages, and changed the nature of chief-farmer relationships (Newbury (1988)). Lineages became obsolete as (mandatory) taxation for government services was introduced (Kagame (1972)).

Rwabugiri was Tutsi. Tutsi chiefs became the norm and preferential treatment towards Tutsi citizens meant the Hutu took a subservient role in society for the first time (Nyirubugara (2013)). Rwabugiri implemented mandatory taxation. Payments were, for the most part, made with cattle, but Hutu didn't traditionally keep cattle so payment with labour (*Ubureetwa*) became a requirement for Hutu. The policy represented a newfound Tutsi dominance and was despised among Hutu. "Of the various services performed for chiefs, *Ubureetwa* 'was the most hated and humiliating.' It symbolized the servitude of the Hutu vis-a-vis the dominant minority." (Newbury (1988)).

When Belgium took control of the colony after World War I, they made changes that inadvertently impacted Hutu-Tutsi relations. They pursued an aggressive export strategy, imposing agricultural requirements on each chief, sub chief and farmer (Bonaventure (2010)). The most aggressive of these policies was the coffee program[14]. A regulation in 1931 made coffee a required crop, stating that *all* chiefs had to grow one thousand trees, sub chiefs were responsible for two-hundred and fifty, while farmers were required to grow fifty-four (Newbury (1988)). Coffee is highly varying in suitability in Rwanda and Burundi (figure 9). The quotas therefore

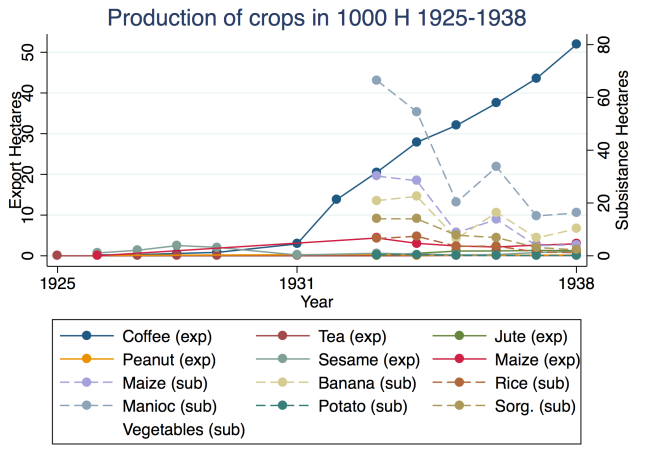
[13]He was the first king to attempt to govern the entire nation. Prior to this kings typically governed only their own territory and received gifts from prominent lineages when lineage chiefs visited. The change in philosophy was partly due to Rwabugiri's own ambition and partly due to the beginning of a cooperation with Germany in 1900.

[14]Some of these programs were fairly innocuous, for example manioc was made a required crop on all farm land. This was to avoid famine, as manioc is robust to various environments and climate changes but manioc for the most part was already being produced on all farms as a subsistence crop.

varied in severity throughout the country.

Coffee quotas influenced agriculture dramatically after 1931 (figure 4.2.1). Coffee went from being one of twenty modestly produced crops to dominating the industry[15]. The quotas replaced subsistence crops, mainly manioc and maize[16]. The true cost of the quotas was therefore related not only to the profitability of coffee, but the opportunity cost of coffee as well. Regions where manioc and maize were very profitable would have been disproportionately affected by the introduction of the quotas. The new requirements pressured chiefs, who, had no knowledge of coffee production in some regions, and were instead profitably growing manioc or maize. Chiefs were displeased with the changes, and plead with Belgium for compromise (Bonaventure (2010)). The Belgians were in the process of abolishing non-monetary taxation (including forced labour) but pressure from the chiefs delayed the abolishment of forced labour in some regions (Newbury (1988)).

Figure 4.2.1: Crop production and prices around the introduction of coffee quotas



Source: Author calculation based on Belgian colonial publications.

Description: This figure shows that the crop quotas were a binding constraint in at least some regions. After coffee quotas were introduced in the early 1931 the amount of land devoted to coffee increased dramatically relative to other export crops. Coffee replaced subsistence crops, and most of the decline came from subsistence manioc and substance maize.

[15]Most of the coffee was of fairly low quality at the time, in stark contrast to the current state of the industry, as the sole focus was on meeting the quotas

[16]These data series are only available starting in 1933

Belgium allowed forced labour in regions where chiefs were not already producing coffee and abolished it, along with other traditional institutions in regions where coffee was profitable. The use of Hutu forced labour (called corvée) therefore increased in regions where coffee was unprofitable but not where it was profitable (Bonaventure (2010)). This meant that, in theory there was no correlation in villages with profitable coffee, but where coffee was unprofitable, forced labour was decreasing in coffee profitability.

This pattern is empirically useful, but only if people couldn't flee areas with forced labour. Otherwise the differential selection out of treatment would undermine the strategy. However, the punishments for rejecting or fleeing forced labour were significant, suggesting that sorting was limited. The standard punishment was *ikiboko*, which means whips with a hippo hide (Butamire, 2012[17]). The Belgians saw the lashings as a traditional punishment, and deemed it acceptable within the culture; "Tutsi overlords [were] being told 'You whip the Hutu or we will whip you.'" (Gourevitch (1998)). Between the threat of violence and the humiliation associated with forced labour, it is reasonable to expect that Hutu attitudes towards Tutsi changed for those that were mistreated[18,19].

[17]New Times web article accessed at http://www.newtimes.co.rw/news/views/article_print.php?14912&a=50565&icon=Print on September 25, 2013

[18]Near the end of the colonial era, ethnic tensions and distrust were volatile. Hutu proverbs demonstrate the extent of the mistrust and stereotypes towards Tutsi (Erny (2005)):

a. When you lodge a Tutsi in your house, he chases you out of your bed
b. What is in the heart of a Tutsi is known only to God and to himself
c. When you heal the teeth of a Tutsi, he bites you as soon as he gets fit

Each statement characterizes the level of mistrust towards Tutsi that the years of dominance and exploitation, at least partly associated with coffee forced labour caused. Each statement implies that Tutsi are opportunistic and untrustworthy (ie. they'll sleep with your wife; are liars; are ungrateful/opportunistic).

[19]This sentiment led to an active anti-Tutsi political movement in Rwanda (PARAHUTU), who took control of the country immediately after independence, and in many places chased Tutsi out of the country. In the early 1960s, Paul Kagame's (Tutsi) family was chased out of Rwanda by PARAHUTU and he lived as a refugee north of the Rwandan border until the genocide in the early 1990s, when he returned and eventually took control of the country, ending 30 years of Hutu rule. Kagame is still in power today. In Burundi, tensions have remained high, but violence has been considerably less; Burundi has not had a genocide. Hutu have remained in power in Burundi since inde-

4.3 Data

To evaluate the impact of colonial era forced labour on economic relationships I have matched a field survey on contracts, lab games between people from 143 villages, data historical forced labour, and GIS data on the historical potential of all major crops in Rwanda and Burundi to construct a dataset that includes detailed information on family history, interethnic trust, economic partnerships and contractual default.

Data on interethnic trust is rarely available to researchers in regions where tensions are especially high because of the sensitivity of the issue. For example, neither the Afrobarometer or the WVS contain trust or ethnicity data from Rwanda because the issue is taboo. Yet observing the economic implications of ethnic tensions is most important in regions with the most contentious ethnic relationships. To overcome this problem, I play the trust game between people, both within and between ethnicities. This allows me to construct a measure of interethnic tensions without making ethnicity salient

Contract data came from a survey done on Hutu and Tutsi coffee farmers. The contracts in the data are insurance agreements which can be of two types. The first is crop insurance, where transfers are made between households producing different crops when one of the crops experiences a bad harvest. These contracts were chosen because we should expect there to be incentives for Hutu and Tutsi to make these contracts with each other. Hutu and Tutsi engage in different types of agriculture - Hutu keep less livestock and grow more crops, while Tutsi keep livestock over allocating land to crop production. Because of this Hutu and Tutsi are less likely to have correlated agricultural shocks when contracts are made across ethnicity than within ethnicity. Because of this insurance is more easily achieved in Hutu-Tutsi

pendence.

contracts.

Forced labour occurred at the village level, and each respondent was matched to their family location during the forced labour era. I construct a measure of village level forced labour exposure in two-steps. First I construct a village level measure of the burden that the quotas had on the village Chiefs, since this was directly related to the use of forced labour. This measure combines data collected on the historical prices of all crops grown in the colonial era with GIS estimates of potential crop profitability per hectare at the village level to construct an opportunity cost weighted measure of coffee profitability. Second, I show the coffee profitability measure is related to Provincial forced labour data, and normalize coffee profitability using it's relationship to forced labour to generate a village level measure of forced labour exposure.

Each of these sources of data is described in detail.

4.3.1 Field Data Overview

Field data was collected in 2 rounds, one in Burundi and the other in Rwanda. In total, the sample consisted of 240 respondents from Rwanda and 380 from Burundi, from 143 different villages. Each round consisted of a number of sessions where people in the same session were potential partners for lab games[20]. Respondents in each session were bussed into the district centre, from between 3 to 6 villages, which were chosen to be as far away from each other as possible, to ensure that potential lab partners didn't know each other. People from the same village were not allowed to be partners.

Participants were surveyed in the local language: Kinyarwandan in Rwanda, and Kirundi in Burundi. Due to dialect differences, different enumeration teams were hired in each country[21]. The surveys, though, were the same in each country, except

[20]On most days, two sessions were completed in a day in both countries, and in each country there were 20 respondents in a session. A session of 20 people took on average 3 hours to complete.

[21]Enumeration training was done in the same way for both teams: I provided supervisor training for both teams. In both cases, supervisors were trained in french. French is widely spoken in urban areas

for one difference due to national culture. Ethnicity is a sensitive topic in Rwanda but not Burundi, so supplementary questions were added in Rwanda to estimate ethnicity.

Each survey had 3 modules, one on the respondents background, a second about their contracts, and a final module for the lab games.

4.3.2 Field Data: Background Module

The background module was used to collect information on education, age, occupation[22], income, land value, migration and ethnicity. The majority of the questions were standard. There were two exceptions: one was related to the problem with asking about ethnicity in Rwanda; the second involved the collection of extensive migration histories, which was a requirement of the empirical strategy.

The larger complication was that ethnicity couldn't be discussed in Rwanda. It has been taboo since the genocide. Instead, in Rwanda, people were asked about various aid programs. For each program they were asked whether they (a) were aware of it (b) were eligible for it, and (c) received money from it. One of the programs was a genocide survivors fund. This is a reparations fund for Tutsi in genocide regions[23]. All respondents were aware of the fund, and since genocide took place in all regions surveyed, differences in responses were not due to genocide exposure[24]. Respondent eligibility for the fund was used as a proxy for Tutsi status.

The other complication was the requirement of family migration histories. For each respondent I collected information on all moves they made throughout their lifetime, as well as the birth place of their parents and grandparents. Their parents

of both countries due to a shared colonial history. Supervisors were from either Bujumbura or Kigali, and spoke fluent french. Supervisors then trained their teams in the local language: Kinyarwandan in Rwanda, and Kirundi in Burindi.

[22]By which I mean primary, secondary crops, percentage of business received from each crop, etc. since they are all farmers in some respect

[23]The specific fund is called F.A.R.G. for "Fonds d'Assistance aux Rescapés du Génocide", which translates to Funds for the Assistance of Genocide Survivors.

[24]This claim is explicitly tested in the robustness section.

birthplace gave a good sense of where their grandparents were farming during the colonial era[25]. The treatment variable was matched to this location.

4.3.3 Field Data: Games Module

As respondents entered the session, they were given a letter-number combination as an ID tag. The letter always corresponded with the village that they were from, and the number uniquely identified within-village respondents. One enumerator was tasked with the job of ensuring that respondents did not play games against other people from their village. We chose villages far enough away from each other that people from each villages would not have met. After completing the survey, respondents played the trust game with the partners that they were assigned. Partners sat down at a table with the enumerator to play the trust game face-to-face.

The trust game worked as follows: People were given 600RWF ($1)[26], which they could share with their partner or keep to themselves. Mean daily wage for the sample was slightly less than 850RWF ($1.33). They were given 6 $100 notes ($200 in Burundi) of Monopoly money, and asked to pass as much money as they wanted to their partner. Whatever they chose to share was doubled by the enumerator, given to their partner, who then decided on how to share that sum. On average 290RWF out of 600RWF was shared with opponents (Table 4.6.1).

Before playing the games, everyone was asked about their partner preferences. They were told that they would play with someone for real money, and that the amount of money they earned would depend on how well they and their partner

[25]Parents of the father are used in all cases where the village provided by the respondent could be mapped. In some instances, villages given did not appear on any of maps I had available. This could be due to enumerator typo/error, poor respondent recollection or change in administrative boundaries and names over time. In a very few cases the respondent did not recall the name of the village and gave the name of the chief or sub-chief in charge of the village instead, and I had no way to properly geocode this information. In these cases, where the father's parents location could not be geocoded, the location of the parents of the mother was used.

[26]Represented by Monopoly money. This is 1200BUF in Burundi

could work together. They were not allowed to choose partners from their village or people they had already met[27]. These preferences were used to test for differential ethnic sorting.

4.3.4 Field Data: Contracts Module

The contracts module started with respondents identifying, from a list, an important business relationship to them. This was done to get some consistency in responses among a heterogeneous population. By far the most common selections were an inter-household insurance scheme (84%) and land sharing agreements (10%). 'Other' was one of the options, but everyone identified one of the options from the list.

Respondents were asked questions about these agreements. The main real world outcome used throughout the analysis was default. The default question asked "Between now and the beginning of the last harvest season, how many times has someone you've had this type of business agreement with failed to live up to their end of the agreement?". The mean number of defaults was 0.93 (table 1), ranging from 0 to 15. 37% of respondents reported at least 1 default, and conditional on any default being reported, the mean number of defaults was 2.5.

People were also asked about the perceived reasons for these defaults. The options included: inability due to sickness or illness; inability due to financial hardship; unwillingness due to lack of interest; and unwillingness due to having found another deal elsewhere that served the same purpose. The vast majority of responses were one of these four[28].

[27] In each session a few people played a game against one of the partners they identified. This is controlled for in all specifications.

[28] There were 3 respondents that did not choose one of these options. One said that their business partner did not live up to their end of the agreement because the written contract was lost, and neither party could remember exactly what the terms were, so the contract was dissolved. A second respondent answered that a business relationship ended mid-contract, due to unrelated family conflict. The

Information collected about the value of these agreements was is used as a benchmark to determine the plausibility of the default estimates. If the estimated lost income was similar to the default rate times the agreement value, it would suggest that the magnitude of the estimates was plausible. The agreement value question asks respondents how much money changed hands in the agreement under consideration.

4.3.5 FAO data on crop potential

Crop potential data came from the FAO, who provided GIS data on the potential produceable tonnes per hectare for each crop across the globe. The estimate of crop potential was calculated using data on climate, soil and terrain. This considered factors such as precipitation, temperature, wind speed, sunshine hours, and relative humidity.

Estimates were available for various input levels. To match historical conditions for Rwanda-Burundi, data chosen were for low-input and rain-fed conditions. The resolution was at the 5 arc-minute level, which is 10km x 10km in Rwanda and Burundi[29]. An example of the crop potential data is shown in figure 4.6.3, which displays the FAO estimates from yield potential for coffee.

4.3.6 Colonial Price Data

Colonial price data for RuandaUrundi was retrieved from Belgian colonial yearbooks. Summaries varied in what they included by year, but for main crops a yearly quantity and value produced was available. The available crops included: maize, rice, sorghum, manioc, potato, sweet potato, banana, peas, vegetables, sugarcane, peanut, sesame, cotton, jute, coffee, cocoa. All crops except for jute were available from the FAO data.

These tables were transcribed for all available crops to build a crop-year panel

third gave an answer that I could not decipher, and it is not clear that they understood the question. These three observations are excluded from the analysis.

[29]Since they straddle the equator and are both very small countries, geographically

containing 368 observations between 1925 and 1950. This data was matched to the FAO data to generate an input-controlled potential revenue number. Because of the input controls in the FAO data, I interpret this measure as potential profit. An example of one of the pages from one of the years is shown in figure 4.6.4.

4.3.7 Forced Labour

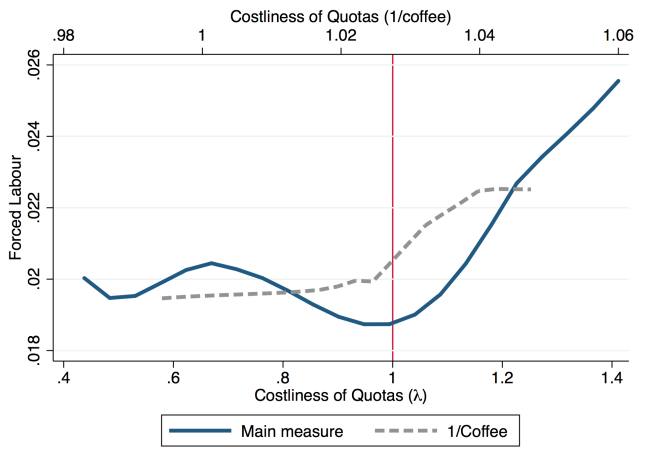
The FAO data and the archival price data is used to generate a measure of forced labour. Because chiefs recruited candidates for forced labour, a direct village level measure on the extent of forced labour use does not exist. To resolve this issue I use the relative profitability of other crops to coffee, which was associated with forced labour use.

A web-scrape demonstrated this as a validation of the constructed measure. The algorithm searched the content of the 30 million books and colonial era reports[30]. The procedure first searched only for the name of a colonial RuandaUrundian province to get the total number of reports and books mentioning the province. It performed a second search for all reports and books that mentioned both the RuandaUrundian province as well as the word "corvée" to get a sense of the number of books about forced labour in that province[31].

[30] Web-scrape was last run on Friday September 20, 2013 at approximately 7:30PM GMT

[31] This will no doubt over count the instances of corvée that are specifically linked to the province in question, as some books will mention several provinces and mention corvée in reference to only a subset of those provinces. However this issue is expected to apply equally to all provinces, and in all likelihood a greater percentage of over counts will occur in the non-corvée provinces indicating that the kink in corvée is under-estimated.

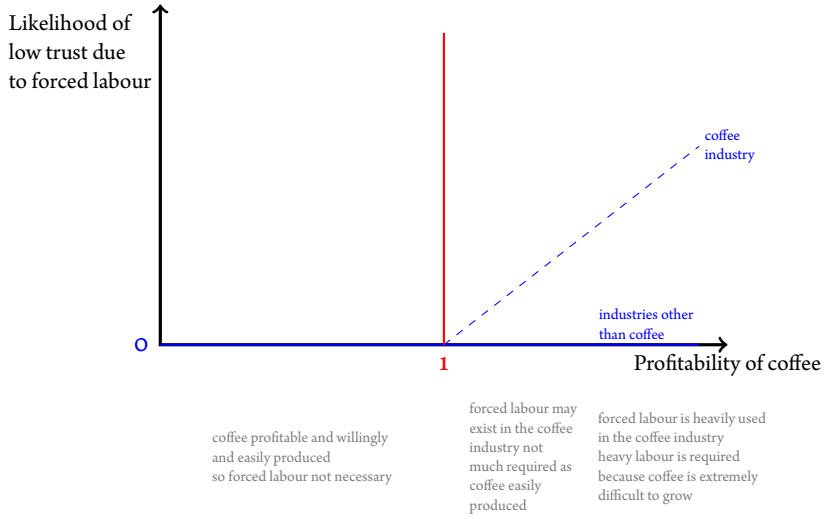
Figure 4.3.1: Relationship between assignment variable and reported provincial forced labour



Source: Author calculation based on a web-scrape algorithm.

Figure 4.3.1 plots this data against the relative profitability of coffee (solid) and one over the profitability of coffee (dashed). The y-axis represents the number of books mentioning both the province name and "corvée" over the number of books mentioning the province name. The relationship shows precisely the association between crop profitability and forced labour described in the historical accounts. Where coffee was profitable - to the left of abut 1 on the graph on the right - there is no obvious relationship between coffee profitability and forced labour. Where coffee was a primary crop - to the right of 1 on the bottom x-axis - forced labour was decreasing in coffee. I use the relative profitability measure (solid line) for the analysis to account for opportunity cost, as figure 4.2.1 clearly implies that it's important. Although either measure would be suitable.

Figure 4.4.1: Assignment of forced labour



Description: The figure shows the assignment of forced labour. The the theoretical kink exists at the industry-location level. Hutu in the coffee industry were eligible for forced labour while Hutu or Tutsi in other industries were not. Forced labour was less heavily used in regions where it was not needed, because there was a cost in terms of political capital both with the Belgians who only reluctantly encouraged it, and with citizens who despised it.

4.4 Empirical strategy

4.4.1 Overview

Two strategies are pursued to identify the effect of history and culture on the strength of ethnic ties. The first is a difference-in-differences design. The first difference is in intensity between historical villages and the second difference is in eligibility for forced labour based on coffee experience. To test the robustness to the possibility that historical contracting environment was related to historical forced labour through institutions, I use an RKD, which can control for historical village characteristics[32]. This design makes use of the abolishment of forced labour in regions where coffee was profitable.

[32]The RKD is attractive due to its ability to identify the treatment on the treated parameter that is identified in a randomized experiment. It, like the regression discontinuity design (RDD), uses a control function approach to account for unobservables, and in doing so can reliably estimate causal effects (Card et al. (2009)). The difference between the RKD and the RDD is simply that the RKD looks for a kink in the outcome which is associated with a kink in the assignment variable, while the RDD looks for a discontinuity in the outcome which is associated with a discontinuity in the assign-

This relationship is illustrated in figure 4.4.1. In the graph the point at which coffee becomes profitable is normalized to 1. To the left of 1 coffee is profitable, and forced labour was abolished by the Belgians. To the right of 1, where coffee is unprofitable, forced labour was allowed up to the point that the quotas were met. Identification in the RKD comes from the change in slope that occurs at 1 on the x-axis, while in the difference-in-differences design, the line at 1 simply needed to roughly delineate where forced labour was and was not abolished.

With the difference-in-differences design, I rely on the fact that individuals in the coffee industry would have been the first ones recruited for forced labour. The specification identifies the difference in outcomes (interethnic attitudes, Tutsi partnership, contractual default, etc) between people with grandparents living in forced labour regions and working in the coffee industry, relative to everyone else. I define Hutu grandparents in the coffee sector as eligible for forced labour on coffee farms.

The following assignment variable allows me to determine which villages experienced forced labour:

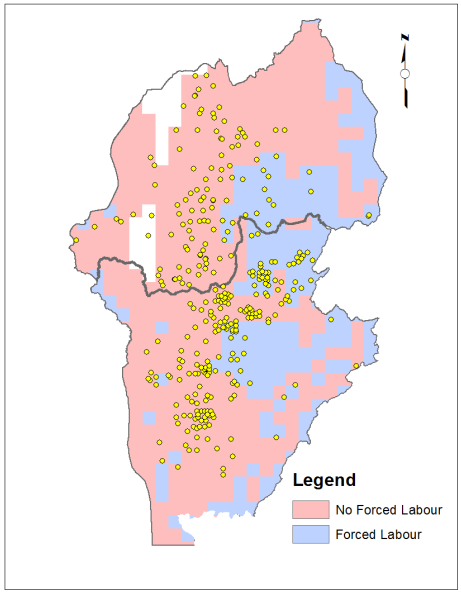
$$\lambda_g = \frac{Max\{OtherCrop\pi_g\}}{Coffee\pi_g} \tag{4.1}$$

$Max\{OtherCrop\pi\}$ varies at the grandparent-village (g) level, and is the maximum of the profit among crops other than coffee. $Coffee\pi$ is the profit from coffee and also varies at the grandparent-village level (g). Profit was calculated by taking the average of the prices from the forced labour period, and multiplying by the input-controlled measure of tonnes per hector for each crop. This variable allows me to determine where forced labour took place. Informed by figure 4.3.1, I define a forced labour region as one where $\lambda_g > 1$. These regions can be seen from figure 4.4.2. The figure

ment variable.

shows regions with and without forced labour, and superimposes the villages of the grandparents of the respondents on top of that. It shows that slightly more than one quarter of respondents had grandparents that were exposed to forced labour. 120 of 400 Hutu respondents had grandparents who were both eligible for forced labour and lived in forced labour villages.

Figure 4.4.2: Forced Labour Regions and Respondent Locations



Source: Author calculation based on data from FAO GAEZ 3.0

Description: The map shows the regional breakdown of forced labour. Dots represent the locations of respondents families in the colonial era, and therefore represents family level exposure to a forced labour. About one quarter of respondents in the sample are from a forced labour village

This threshold allows me to define a forced labour intensity variable.

$$FLIntensity_g = \begin{cases} 0, & \text{if } \lambda < 1 \\ \lambda, & \text{otherwise} \end{cases} \tag{4.2}$$

The forced labour intensity is then interacted with an eligibility for forced labour variable in the differences-in-differences specification. Any individual that was a member of the coffee sector is defined as being eligible for forced labour. The

differences in differences design is fairly simple.

$$\begin{aligned} Outcome_{ivg} &= \beta_0 + \beta_1 FLIntensity_g \cdot Eligible_{ig} + \beta_2 FLIntensity_g \\ &+ \beta_3 Eligible_{ig} + \alpha X_i + \gamma_v + \varepsilon_{ivg} \end{aligned}$$

Where i is an individual, v is a the village the respondent currently lives in, and g is the village the respondents grandparents lived in. X_i represents a vector of controls which includes education, age, gender and enumerator fixed-effects[33]. $Eligible_i$ captures the idea that only coffee farmers would have been selected for forced labour, and represents the share of grandparent agriculture devoted to coffee. β_1 was the variable of interest because it distinguishes individuals whose grandparents were most exposed to forced labour, being both in in a forced labour village and being in the coffee industry.

The main identification concern with this specification is the historical contractual environment. The worry was that historic contractual environment was related to coffee profitability through altitude since colonial penetration has been linked to ruggedness (Nunn and Puga, 2011). This issue is addressed in two ways using the difference-in-differences design.

The first uses Tutsi as a falsification group, as Tutsi were not eligible for forced labour. If the Hutu sample results are replicated using the Tutsi sample, this would be a strong indication that the estimates were not due to forced labour, but rather to

[33]The concern is that behaviours or answers regarding interethnic trust may have differed when a Tutsi enumerator interviewed a Hutu respondent than when a Hutu enumerator interviewed a Hutu respondent. The ethnicity of the enumerator is captured by the enumerator fixed effects. It is illegal in Rwanda to ask employees their ethnicity, so controlling simply for enumerator ethnicity is not possible. Enumerators were assigned to respondents randomly. The same enumerators always interviewed the same ID numbers and ID numbers were assigned randomly. They only deviated from this system when sessions got significantly behind schedule, and enumerator supervisors picked up the slack in these cases. Given the random assignment of ID number, controlling for enumerator fixed effects should not be picking up any selection effects or introducing any other endogeneity.

historical institutional quality. The second strategy controls for coffee productivity directly, so that identification relies solely on the opportunity cost of coffee. Since the concern was that institutional quality was related to the amount of coffee that could be produced (i.e. the 1,000RWF), controlling for coffee, and identifying an effect solely from the profitability of the next best crop, alleviates this concern.

Another strategy to overcome this issue is to test a RKD, which compares people with nearly identical historical family locations. If this assignment variable were applied to a classical RKD specification[34], the specification would be:

$$\begin{aligned} Outcome_{ivg} &= \beta_0 + \beta_1 \lambda_g \cdot [\lambda_g > 1] + \beta_2 \lambda_g + \beta_3 [\lambda_g > 1] + \beta_4 \lambda_g^2 + \beta_5 \lambda_g^3 + \beta_6 (\lambda_g \cdot [\lambda_g > 1])^2 \\ &+ \beta_7 (\lambda_g \cdot [\lambda_g > 1])^3 + \alpha X_i + \gamma_v + \lambda_e + \varepsilon_{ivg} \end{aligned} \tag{4.3}$$

This would still rely on the change in slope in regions where coffee was unprofitable, but would also include a control function which would imply that identification would come from observations on either side of the 'kink'. In this case the comparison would be between people whose grandparents lived in nearly identical villages, so that historical contractual environment would not confound estimates. β_1 would be the variable of interest because the interaction term $\lambda \cdot [\lambda > 1]$ would capture the change in the correlation between λ and y after the 'kink', which occurred at $\lambda = 1$.

This specification, however, can be improved on. It doesn't take advantage of all of the data. By doing so, the identification assumption required can be weakened. Information is available about people with, and without, forced labour histories on the right side of the 'kink' because there are people in forced labour villages that aren't eligible for forced labour. Like in the difference-in-differences design, I can take

[34]Which it is in the genocide table as well as a main effect robustness table in the online appendix.

advantage of the fact that only those with knowledge of coffee were chosen for forced labour. Non-coffee farming Hutu can act as an additional 'control-group' to the right of the kink. Instead of just measuring the kink, I can measured the differential kink between those with and without a family coffee history[35]. To measure the differential kink between those likely and unlikely to have been selected into forced labour, I ran the following regression:

$$\begin{aligned} y_{iveg} &= \beta_0 + \beta_1 \lambda_g \cdot Eligible_i \cdot [\lambda_g > 1] + \beta_2 \lambda_g \cdot Eligible_i + \beta_3 \lambda_g \cdot [\lambda_g > 1] \\ &+ \beta_4 Eligible_i \cdot [\lambda_g > 1] + \beta_5 \lambda_g + \beta_7 Eligible_i + \beta_8 [\lambda_g > 1] + \beta_9 \lambda_g^2 \\ &+ \beta_{10} \lambda_g^3 + \beta_{11} (\lambda_g \cdot [\lambda_g > 1])^2 + \beta_{12} (\lambda_g \cdot [\lambda_g > 1])^3 + \alpha X_i + \gamma_v + \varepsilon_{ivg} \end{aligned} \tag{4.4}$$

This 'differential RKD' (equation 4.4) measures the difference in the kink between people with and without grandparents in the coffee industry. It takes the 'classic RKD' (equation 4.3) variable of interest $\lambda_g \cdot [\lambda_g > 1]$ and interacts it with the $Eligible_i$ variable, making the specification a hybrid between a regression kink design and a difference-in-difference design. *Eligible* was added on its own and interacted with each of λ and $[\lambda > 1]$, as in the difference-in-differences design. The parameter of interest was β_1.

4.4.2 Other Identification Concerns

Income

It could be that the income reduction due to quotas was stronger in the coffee sector than in the non-coffee sector. Just as chiefs disproportionately chose people in the

[35] The main results were tested using both the variation in the RKD and the classic RKD and the results are similar. The variation has implications for the confounding effects of income, and strengthen the design. This will be discussed later.

coffee sector for forced labour, they may have placed more of the coffee quota burden on coffee farmers in places where the quotas were especially unpopular. To account for this possibility, income was separately instrumented for using predicted income. The prediction was based on grandparent land characteristics and was included in the control vector X. Predicted income was:

$$\hat{inc}_g = \alpha + \rho[Suitability_g] + \omega_g \tag{4.5}$$

Predicted income is highly correlated with income ($\rho = 0.814$). All results are robust to specifications with and without the control, suggesting that a direct income effect resulting from forced labour is not driving estimates.

Migration

Other identification concerns that are dealt with using falsification tests. For example, while migration allows for the current village fixed effects, *differential* migration may be problematic. People with a family history of forced labour may have been more likely to migrate three generations ago. Identification relies on migrants because of the fixed effects, so a migrant vs. non-migrant comparison will not harm identification. But if recent migrants were treated differently from third generation migrants, this could potentially be an alternative explanation for the estimates.

To address this concern, I tested for differential migration at each generation since the forced labour era. This falsification test revealed no significant differences in migration among grandparents, parents or respondents themselves. I also looked at the related McCrary density test. If people fled from forced labour, the density of Hutu whose grandparents grew coffee would not have been smooth at the kink. I found no evidence that this was the case.

Other identification issues

There were a number of other identification issues that were addressed. The evidence ruled out differences at the industry level confounding results. I found no difference using treatment at the current village level as a placebo. There was no difference in estimates when looking at Burundi only, so the effect was not due to the measurement error associated with ethnicity in Rwanda or the Rwandan genocide.

4.5 Results

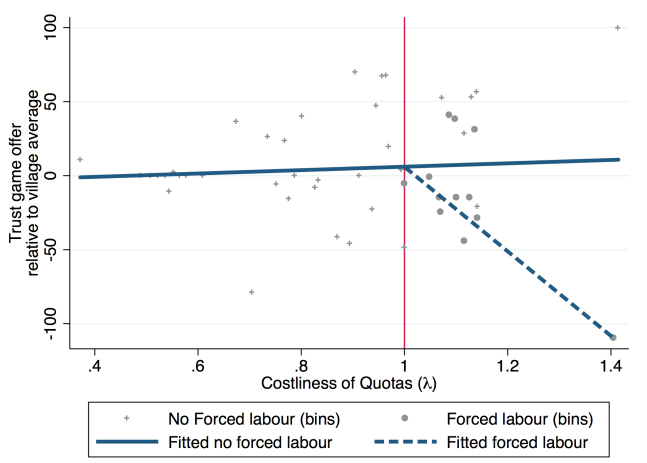
First I document a source of exogenous variation in interethnic attitudes. I show this variation is associated with economically relevant behaviour in the lab as 'treated' people are more likely to sort along ethnic lines into potentially profitable partnerships. I then analyze real world default which is consistent with this behaviour, suggesting a relationship between culture and income. Evidence suggests that this mechanism reduced income by the expected amount.

4.5.1 Ethnicity and attitudes

I start by documenting interethnic resentment, measured using offers in the trust game. Trust game offers by the three factors that determined forced labour eligibility are shown in figure 4.6.2: (1) ethnicity, (2) agricultural industry and (3) coffee profitability. There are no obvious differences in these distributions. The variance is higher for people whose grandparents were out of the coffee industry and people whose grandparents were in a forced labour village, but not significantly so.

Differences are more apparent when looking at mean offers jointly by ethnicity and region. Hutu in forced labour regions made slightly lower offers than everyone else (table 4.6.1). But these include offers to same and opposite ethnicities, and don't

Figure 4.5.1: Interethnic attitudes and grandparent forced labour



control for local institutions, so they're only partially revealing. Figure 4.5.1 better illustrates that these differences are due to forced labour.

The figure reveals the expected relationship for the subsample of Hutu respondents that played the trust game against a Tutsi. The graph demonstrates the change in interethnic attitudes associated with differences in forced labour intensity. To the left of 1 are villages where coffee is a primary crop and there would have been no forced labour in these villages. To the right of 1 are forced labour villages. Within these villages some people would have been selected into forced labour and some would not have been. Those likely to have been exposed to forced labour are denoted with a dot, while the control group is denoted with a plus. Forced labour intensity is increasing for the exposed group to the right of 1, and this is associated with a sharp decrease in interethnic trust game offers from Hutu to Tutsi.

The estimates of these differences are in table 4.6.4, which presents the effect of forced labour on interethnic attitudes. The table splits the estimates by sample, into Hutu-Tutsi games with Hutu offers (Panel A), Tutsi return offers (Panel B) and Hutu-Hutu games (Panel C). Columns (1)-(2) show the difference-in-differences

specifications with and without the coffee profitability control. Controlling for coffee profitability directly helps to account for the possibility that historical institutions were related to altitude and therefore correlated with coffee profitability. It means that identification comes from solely from the opportunity cost of growing other crops. Columns (3)-(4) show the RKD using a cubic (column 3) and quintic (column 4) control function.

Both designs consistently estimate that Hutu attitudes towards Tutsi worsened due to forced labour. All estimates were normalized by the standard deviation of reported forced labour, and the RKD estimates were normalized by the kink in the forced labour data, as described in Card et al. (2009), to generate estimates whose magnitudes can be compared to the difference-in-differences magnitudes. The standard deviation in the forced labour data was about 0.3 and the estimated kink was about 15. These normalizations mean that the estimates in table 4.6.4 can be interpreted as the effect of a 1SD increase in forced labour on interethnic trust game offers. Hutu offered 85-115RWF less to Tutsi in the trust game when their grandparents were exposed to 1SD more forced labour.

This reduction in trust was unjustified since Tutsi did not return significantly less when partnered with someone whose grandparents were likely to have been exposed to forced labour (Table 4.6.4, Panel B). Panel B includes an additional control for the amount initially offered, so that returns were not lower simply because there was less to share. Offers were slightly lower, but are consistently about half of the magnitude of the Hutu effect.

The impact on mistreated Hutu was not a general trust effect (Table 4.6.4, Panel C). This would have been problematic for the interpretation. If the effect was a general one, there would be less reason to expect a change in partner types. In this case though, the offers from (mis)treated Hutu to other Hutu was positive. This is

consistent with the idea that (mis)treated Hutu became more reliant on their ethnic network as resentment towards Tutsi increased. The effect was not significant, but the magnitude was relatively large, averaging about 2/3 of the main interethnic games estimate.

The increase in resentment towards Tutsi may have impacted the economic relationships of other Hutu[36]. If mistreated Hutu sort away from potentially profitable relationships with Tutsi because of their resentment, then this should have important economic ramifications. The next section tests whether Hutu with a family history of mistreatment are more likely to discount profitable opportunities with Tutsi in favour of another Hutu.

4.5.2 Ethnic Sorting

I focus on the economic implications of trust, starting with partner selection. The test for sorting in economic relationships relies on lab decisions about partner preference. Participants were asked to select five individuals that they wanted to be partnered with in the trust game. Enumerators told them that whether or not they would be partnered with any of their selections would be randomly determined.

The measure identified the ethnicity, income and occupation of each selection. Tutsi averaged 36% of each session, but on average only 20% of partner selections were Tutsi. So unsurprisingly given the context, ethnicity was a factor in people's decisions. I test whether this ethnic sorting was more likely among people with grandparents that were mistreated. This would be consistent with evidence showing

[36]This table also compliments some of other literatures. It confirms that attitudes are historically determined. Nunn and Wantchekon (2012) have previously documented that trust is correlated with the slave trade. The table shows the same result is robust to a smaller scale event. The slave trade took place from the 16th to 19th centuries, whereas forced labour in the coffee industry lasted from 1930 until about 1955. Even an episode that lasted only 25 years persists more than 50 years later. This evidence also contributes as it is specific to interethnic attitudes, uses incentive compatible measures, and explicitly measures family level exposure. The evidence confirms theoretical findings from Tabellini (2008) that elements of culture are transmitted within families, across generations.

that resentment towards Tutsi was greater among mistreated Hutu families.

The tendency of people from mistreated families to sort ion Hutu-only partnerships was confirmed in table 4.6.3 panel A. The difference-in-differences estimates in column (1) and (2) of table 4.6.3 show that forced labour caused a 10% decrease in the probability of selecting a Tutsi partner. The RKD estimates were higher, with an estimate over 30% using the cubic polynomial control function in column (3) and an estimate of about 15% using a quintic polynomial control function in column (4). Regardless of specification the effect does not seem to be driven by historical institutions.

One worry with this result was that it was possible that ethnicity and income were correlated, and that people were trying to choose other low income partners rather than Hutu partners. This hypothesis was tested in table 4.6.3 panel B. The outcome is similar to the Panel A outcome. It's a binary variable measuring the percentage of partners selected that had an income above the median. None of these estimates were statistically significant, although the magnitudes were positive and fairly large. People may have preferred higher income partners if their grandparents were exposed to forced labour. Positive estimate were not be as worrisome as if the estimates were negative, as a positive estimate goes in the opposite direction of the potentially confounding effect. If the estimates were negative it would have been difficult to separate whether economic consequences were due to sorting on ethnicity or sorting on low income.

A similar exercise tested for sorting by occupation. Panel C shows that people were slightly less likely to sort into partnerships with other coffee farmers though. The estimates are close to 0 and statistically insignificant. It would have been problematic if the treated group were more likely to be coffee farmers, sorted into relationships with other coffee farmers, and coffee farmers were poor economic partners.

Since ethnic sorting existed in the lab, it may also have existed in the real world. This would have implications for economic relationships, and could help explain the tendency to rely on ethnic economic networks, as well as the implications of this for the sustainability of these relationships. When some Hutu discount a potential Tutsi business partner, they may choose a less good match on average, increasing default at the margin. This hypothesis is testable. Next, I examine whether the people with different attitudes and behaviour in the lab experienced more default in the real world.

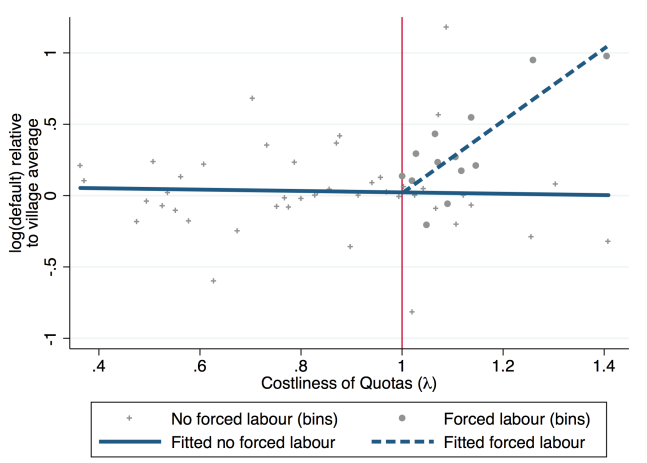
4.5.3 Default

Due to the ethical concerns I don't observe whether real world relationships were same or mixed ethnicity. However, I can observe whether default is more likely for Hutu than for Tutsi with grandparents from forced labour villages. While documenting the number of real world interethnic relationships would have been useful, the mechanism causing differences in default operates through defaults on same ethnicity relationships.

I start by individually examining the three factors that determined forced labour eligibility: (1) ethnicity (2) family crop history and (3) grandparent location. There are little to no differences in these comparisons as, within each factor, people with and without a forced labour history existed. The distribution of default for each of these three factors with respect to default is shown in figure 4.6.2. The distributions were nearly identical in all three cases.

Comparing Hutu from families exposed to forced labour with everyone else, the effect becomes more clear (Table 4.6.1). Default for Hutu in regions where forced labour was prevalent is about 15% higher than everyone else. Each of the other groups experienced nearly identical default rates. This comparison doesn't account for a coffee history though, and doesn't control for current village effects.

Figure 4.5.2: Contractual default and grandparent forced labour



The figure reveals the expected relationship for the subsample of Hutu respondents. The graph demonstrates the change in contractual default associated with differences in forced labour intensity. To the left of 1 are villages where coffee is a primary crop and there would have been no forced labour in these villages. To the right of 1 are forced labour villages. Within these villages some people would have been selected into forced labour and some would not have been. Those likely to have been exposed to forced labour are denoted with a dot, while the control group is denoted with a plus. Forced labour intensity is increasing for the exposed group to the right of 1, and this is associated with a sharp increase in default among Hutu.

The analogous estimates, are in table 4.6.4. The sample was separated by ethnicity to show that the increase in default was specific to Hutu (Panel A) and not Tutsi (Panel B) who were not exposed to forced labour. Estimates were consistent with the hypothesis that grandparent forced labour increased default. Column (1) and (2) tested the difference-in-differences estimates while columns (3) and (4) tested the cubic and quintic polynomial in the RKD specification shown in equation (4.4). The estimates were nearly identical[37] and each specification estimated that a 1SD increase

[37]All estimates were also run both with and without education, age, gender, grandparent country

in forced labour resulted in a 28% increase in contractual default. The similarity of the estimates reinforces the idea that estimates are not driven by historical differences in contracting environment.

This same pattern was not present for the Tutsi subsample, further confirming that the effect was unlikely to be due to other historical village characteristics. Tutsi from forced labour regions were actually less likely to experience contractual default, with estimates about as large as the Hutu estimates, but going in the opposite direction. This could be for a number of reasons. There were reports in the history literature that Tutsi were especially favoured in forced labour regions, so the effect could be related to that. Alternatively, it could be that Tutsi were able to pick up more profitable opportunities when (mis)treated Hutu sorted out of these opportunities. Or it could simply be due to outliers, as the effect is not significant.

The evidence implies that the lab measures reflect behaviours that exist in real economic relationships. Forced labour altered resentment, and default. The evidence suggests that this occurred as (mis)treated people ethnically sorted and chose poorly suited contractual partners. If this was true, the majority of defaults would have been due to a low ability of contractual partners.

4.5.4 Default due to ability

I infer real world ethnic sorting by analyzing the reasons for default. If ability is the primary reason driving default, it implies that people who discriminated selected business partners from a shallower ability pool. Ex ante, we might instead believe that default is driven by the effort of the contractual partner. Suppose ethnic sorting does not exist in the real world. It seems plausible that Tutsi would be less motivated to

controls, and are robust to all combinations of controls. Estimates presented are with controls. Standard errors are presented clustered by assignment-variable bin (0.01) as well as grandparent village location. Results are robust to both.

provide high effort in economic relationships with people who discriminate against them. Both the sorting mechanism, and the effort mechanism are tested separately. I find evidence that defaults come from Hutu-Hutu relationships, since partner match is the dominant reason for default. I find no evidence for the effort mechanism.

If the proposed ethnic sorting mechanism is true, default should be generated by low ability to fulfill a particular contract, rather than poor effort. To measure this, respondents identified an instance of default during the past harvest season, and information was collected on whether they experienced defaulted due to low ability or low effort. They were given specific options: (a) found a better deal elsewhere; (b) no longer have the financial ability to continue with the agreement; (c) no longer have the ability to continue with the agreement due to illness or injury; (d) simply lost interest in the agreement; (e) other (specify).

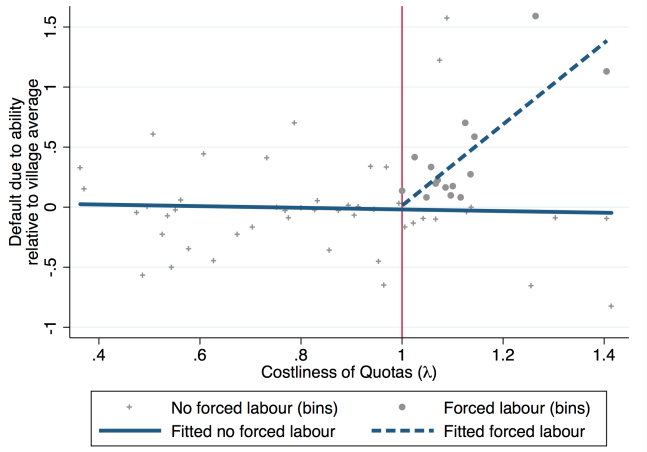
Options (a) and (d) were categorized as low effort. While option (a) is not precisely low effort, it is typically classified as ex-post moral hazard, or strategic default[38]. Options (b) and (c) are both related to low ability, and were used in the test for poor partner selection[39].

The figure reveals the expected relationship for the subsample of Hutu respondents. The graph demonstrates the change in contractual default due to the ability of the contractual partner to make a transfer, associated with differences in forced labour intensity. To the left of 1 are villages where coffee is a primary crop and

[38]Differentiating between ex-post and ex-ante moral hazard is not a focus of this study (see: Blouin and Macchiavello (2013)), but to ensure that both types were not driving default, these were examined separately in the next subsection.

[39]This method is not without fault. When default occurs, excuses are certainly more likely to involve aspects out of the defaulters control, to avoid suspicions of malice. This will bias excuses towards ability and away from effort. However, it seems unlikely that this source of bias would differentially impact those whose grandparents were eligible for coffee forced labour. Furthermore, villages in the sample are very small. It seems fairly plausible to assume that profit related lies would be difficult to successfully pursue due to the density of within village networks in small communities. Regardless, the potential for bias does exist, and interpretations should proceed with caution.

Figure 4.5.3: Default due to partner ability and grandparent forced labour



there would have been no forced labour in these villages. To the right of 1 are forced labour villages. Within these villages some people would have been selected into forced labour and some would not have been. Those likely to have been exposed to forced labour are denoted with a dot, while the control group is denoted with a plus. Forced labour intensity is increasing for the exposed group to the right of 1, and this is associated with a sharp increase in default due to ability among Hutu, suggesting that these Hutu are engaged in partnerships of lower quality.

Panel A of table 4.6.5 shows that Hutu from forced labour families differentially perceived the biggest reason for default as being ability. Columns (1)-(2) show the estimates from the difference-in-differences specification and columns (3)-(4) show the RKD estimates. Again, results are extremely robust to the various specifications which test the robustness to historical village characteristics in different ways. All estimates produce large magnitudes for default due to ability at around 45%. The mean of both ability and effort based defaults were similar in the data, with respondents averaging about 0.56 ability based defaults and 0.69 effort based defaults (Table 1) in the past harvest season. Comparing the 45% estimate with the 28% increase in default of any type, this means that almost all of the defaults identified in

the previous table were due to the ability of the partner to fulfill their end of an agreement. The estimate would be about 60% ($0.28/\frac{0.56}{0.56+0.69}$) if all of the overall defaults were driven by ability defaults, which is within the confidence intervals of the actual estimate.

Panel B shows estimates for the Tutsi subsample. One concern was that the effect was not specific to those eligible for forced labour, but instead related to an interaction between the coffee industry and grandparent village institutions. The Tutsi subsample rules out this concern. Absolute magnitudes were all about 1/3 of the Hutu sample counterparts, and the sign goes in the opposite direction for two of the 4 estimates. All Tutsi estimates are imprecisely estimated and not significantly different from 0. Panel B of table 4.6.5 showed that there's no concern that grandparent village characteristics are confounding Hutu estimates.

If the partner match was the mechanism driving differences in default, then there should not be an increase in effort based defaults. I tested this directly in panel C, which confirms the hypothesis. All estimates are less than 1/4 the magnitude of the ability estimates, and are highly imprecise. Still though, it could have been that effort was a problem, but we don't see low effort in equilibrium because contract type adjusts to overcome the concern. If incentive based contracts increased, this could mean that there was an increased threat of low effort. However, panel D shows that this was not the case. Incentive based contracts were not more likely to be used by people with a family history of forced labour. Like the effort based estimates in panel C, all estimates are close to 0 and highly insignificant.

While real world ethnic sorting data was not possible to collect, a strong inference can be made that sorting was affected by forced labour, and the changes in attitudes that it created. Hutu with historically induced resentment towards Tutsi chose different partners in the lab, and experienced more default. All of the additional

defaults came from the ability of their contractual partners to fulfill their end of an agreement. This strongly suggests that the strength of economic ties can be due to history and culture rather than solely determined by contractual environment. In this case the causal direction was reversed. History and culture altered the contractual environment for some, through their partner decisions, which led to an increase in defaults.

4.5.5 Other Economic Outcomes

Given strong evidence of poor partner selection and the resulting default, I expected lower income for Hutu. I estimate the impact on income. Table 4.6.6 shows the effect on income, of a grandparent being exposed to forced labour.

The estimates in Panel A show the main effects for the Hutu subsample. As expected these individuals had lower income, by between 15% and 27%. The difference-in-differences model (columns (1) and (2)) produce the larger 27% estimates, with the RKD estimates (columns (3) and (4)) averaging about 15%. The 27% number seems too large, but the 15% number may be reasonable. The concern is that there was a direct effect on income which was not related to the change in culture or defaults.

To get a sense of what would be a reasonable magnitude, I benchmarked the estimates against the default estimates and the agreement values which are solely used for external validity, value was not included in any of the empirical models. The average agreement value is about $67, and the estimated increase in defaults was about 30%. If all of the estimated income effect came from an increase in defaults, this would represent about $20 ($67 \cdot 0.3$) per harvest season, which would be a 12% reduction in average income. The 15% estimate is therefore more reasonable than the 27%.

The 3% difference between the benchmark and the model estimate could be due to

the Tutsi opportunities that are not taken and not substituted with Hutu contracts. I expect the income estimate to be larger than the benchmark estimate because resentment has two effects on income. First, it increases defaults, which can be benchmarked. Second, it means that some opportunities are lost, and not replaced with similar Hutu opportunities. This is not captured by the default estimates but is captured by the direct income estimate. So if missed opportunities had as large an effect on income as increased defaults from substituted opportunities, then the difference-in-differences estimates may be reasonable, otherwise the RKD are more reasonable. All I can say on this is that lost income due to missed opportunities is estimated as being between 3% and 15% of income.

One reason that could be driving differences between the RKD and difference in differences estimates could be the historical village characteristics. Therefore, it may only be reasonable to believe that the change in resentment was the only source of economic change with the RKD estimates.

4.5.6 Robustness and falsification tests

Migration caused by forced labour

One identification concern is that forced labour caused migration, and migrants may have been treated differently from non-migrants. But the village-fixed effects ensure that the comparisons were made between individuals who have migrated at some point in the past three generations. Still, recent migrants may have been treated differently than third generation migrants, so I test for differential migration at each generation.

The migration variable I use measures whether the settlement locations differed between (a) grandparent and respondent; (b) parent and respondent; and (c) the length of time the respondent has lived in their current location (controlling for age).

Each measure is analyzed using the full sample, and the Hutu-only sample.

Columns (1) and (2) of table 8 show that both for the difference and differences design and RKD, mistreated Hutu were less no more or less likely than average to migrate. Both estimates are very close to 0 and highly insignificant, and they go in opposite directions. If forced labour caused migration the Hutu estimate in column (2) would be positive and significant. Columns (3) and (4) perform a similar exercise but at the parental level. Again, estimates are very small and insignificant, although those whose grandparents were exposed to forced labour had parents that were slightly more likely than average to move. In columns (5) and (6) I investigated mobility by the respondent, by analyzing the amount of time they have lived in their village. The estimates from the two samples are very similar, both showing that respondents with grandparents from forced labour villages in the coffee industry were about 2 years newer to their village than others. This estimate is very small, and unlikely to make much of a difference. On average, respondents have been living in their current village for over 25 years.

There was little worry that forced labour caused differential migration patterns. The causal interpretation of the relationship between culture and default is strengthened by the small, imprecise migration estimates.

Falsification - Sorting around the threshold

A related check is the McCrary (2008) test for selection out of treatment. Given the migration results this is an unlikely explanation for the results. Historically, prior to the introduction of quotas, there was no selection on coffee land due to the insignificance of the coffee industry in the region. Farmers did not want to grow coffee intensely, and would therefore not have selected into (or out of) land that was suitable for coffee production. Once forced labour was introduced, it would have

been difficult for those who were eligible to move to new regions, by the *forced* nature of the policy. There were strict and brutal punishments for trying to avoid forced labour, which chiefs and sub chiefs had strong incentives to enforce.

That said, there were also strong incentives to avoid forced labour. To address this, the standard McCrary test for sorting at the threshold was run, and is presented in table 4.6.8. The test divided the sample into bins based on the assignment variable, and tested the density of respondents within each bin on either side of the threshold. The idea behind the test is most easily seen in figure 4.6.1. The figure shows the density of Hutu on the right and the left of the threshold. The panel on the left shows that there was no change in slope in the density of Hutu on either side of the threshold, and the graph on the left shows that there was no discontinuity in the slope either.

Both the table and figure show that no sorting[40] took place. Columns (3) and (4) of table 4.6.8 show that if anything there is a small increase in density to the right of the threshold. On the overall sample, the sign flips direction, indicating that it is very unlikely that Hutu fled from forced labour regions. If anything Tutsi were more likely to flee forced labour regions than Hutu. This is understandable. There would not have been punishments to the Tutsi for 'fleeing', and it would have been costly to continue to farm on land unsuited to coffee production.

Based on this, I concluded that there was no Hutu selection out of treatment. Given the sudden, unexpected and arbitrary nature of assignment, the variable used was appropriate for the two designs.

[40] or related sampling problems

Another concern is the effect of the genocide on answers to the ethnicity proxy in Rwanda. It may have been possible that Tutsi were more likely to identify as such in regions where genocide violence was more prominent. This could cause measurement error which was correlated with the change in slope. If forced labour did impact resentment, it may have influenced interethnic violence. To address this I employed the classic RKD (equation 4.3) to see whether forced labour is associated with the genocide.

The data was based on prosecutions by the *Gacaca courts* which were established after the genocide to deal with genocide crimes[41]. There were three categories of violent crimes associated with the *Gacaca courts*. Category 1 was for people who planned the genocide, or who committed especially horrible crimes, like murder, rape or sexual torture. Category 2 was for people who committed violent crimes with the intent to murder, rape or sexually torture, but whose actions did not necessarily result in these outcomes. Category 3 was for people who committed violent crimes, but without the intent to murder, rape or sexually torture. The data came at the village level[42] and was aggregated to the level of cells in the FAO crop data[43]. Population data at the village level came from GeoDynamics, and were matched by village name to the violence data[44].

The columns of table 4.6.9 Panel A were split into categories based on the severity of the crime. Column (1) shows the worst crimes (category 1), column (2) shows category 2 crimes and column (3) shows the least severe crimes. The colonial policy had a significant positive impact on each of the three categories of crime, so there is a

[41]This was done so as to not overwhelm the traditional court system.

[42]Village elders are often placed as judges in these courts.

[43]There are over 1500 villages, and only 276 geographic cells, so the coarser geographic cell is used as the unit of analysis.

[44]These are the same genocide data used in Yanigazawa-Drott (forthcoming)

legitimate concern regarding the impact of the genocide on measurement error.

To deal with this the main specification is tested on the Burundi sample in Panel B. The first two columns test the difference in differences design, and columns 3 and 4 test the RKD. In Burundi there was no genocide, and ethnicity could be asked directly so there was no measurement-error concern. The estimate was nearly identical to the combined Rwanda/Burundi estimate, ranging from -70 to -92, and remain highly significant (despite halving the sample size) suggesting that the assignment of ethnicity in Rwanda was not considerably different from the assignment of ethnicity in Burundi.

Colonial forced labour was a contributing factor to the genocide in Rwanda. A full analysis of this is beyond the scope of this paper and left for future work, but this finding contributes to a literature on the causes of conflict[45]. The evidence shows that this is not confounding estimates.

Falsification - Alternate crops and location

A third concern could be that the results are not specific to the coffee industry, but derive from the insular nature of more specialized industries. People with less diverse production, may have required less socialization outside a small network of other highly specialized people. This could have altered attitudes. To account for this possibility, I ran the same specification on other prominent crops in the region which are, in some areas, highly profitable[46].

The differential RKD based on equation 4.4 using relative profitability to each of

[45]See Blattman and Miguel (2010) for a review. Much of the debate regarding ethnic conflict centres around the "primordialist" versus "modernist" views which pit deep biological or psychological roots against power struggles, respectively. The evidence that forced labour caused genocide contributes by demonstrating that in at least some cases, the modernist argument prevails.

[46]This specification can only be run on the subset of crops that were, in some regions, the most profitable crops. This is because of the nature of the assignment variable, which calculates the relative profitability of a crop, and measures a kink around the point at which a given crop becomes the most profitable in a region.

these crops as the assignment variable is shown in table 4.6.10. There were 5 other crops that were, in some regions, the most profitable crop to produce. They were: manioc (column 1), cotton (column 2), sugarcane (column 3), rice (column 4), and banana (column 5). None of the other crops was close to showing a similar relationship to the coffee industry. Every estimate was close to 0 and highly insignificant[47]. Each of the estimates restricted the sample to those playing mixed ethnicity games and use a cubic polynomial, so estimates were analogous to their coffee counterpart in table 4.6.4 column (1).

A final concern is that while there is something unique about the coffee industry, there is nothing unique about the family location around the time of forced labour. Historical family location may simply be correlated with current location attributes that cause differences in attitudes[48]. To address this concern, the differential RKD (equation 4.4) was analyzed with the modification that suitabilities associated with current respondent location were used instead of historical family location[49].

These results are shown in table 4.6.11. Again, the estimates are close to 0 and highly insignificant implying that there is something unique about the family location during the colonial era. The results are not driven by any correlation with contemporary crop suitabilities.

4.6 Conclusions

This paper uses the historical exposure to forced labour as exogenous variation in Hutu attitudes towards of Tutsi in Rwanda and Burundi to show that resentment can

[47]The only other crop which even shows a negative estimate is manioc, which is the other crop to have been associated with quotas, although not nearly on the same scale.

[48]Due low fairly low mobility in the area, it is very likely that historic relative profitability is highly correlated with current relative profitability.

[49]To analyze the regression in this way, the village fixed effects are removed and replaced with historical family location fixed effects to capture the effect of historical forced labour.

have costly economic consequences. While culture has been thought to be important in a variety of economic outcomes, this may be a surprising result due to the highly plausible alternative that default is the causal driver of any observed correlation between cultural attitudes and default.

The evidence suggests that poor partner selection is, in part, a cultural phenomenon. Resentment based on ethnicity causes sorting into same-ethnicity economic relationships. This causes indignant Hutu to pass over high quality prospective Tutsi business partners in favour of less reliable Hutu partners that are more likely to default. There is, perhaps surprisingly, little evidence supporting the idea that resentment can induce low effort from a business partner and cause default. This could be, in part because sorting is so prominent that there are not enough Hutu-Tutsi relationships in (mis)treated regions to observe reductions in default due to low effort.

Tables

Table 4.6.1: Summary statistics

	Panel A: Outcomes - Forced Labour Regions					
	Hutu			Tutsi		
Variable	Mean	Std. Dev.	N	Mean	Std. Dev.	N
log(Default)	0.471	0.626	146	0.405	0.619	56
Income (USD)	265.73	574.89	142	302.34	611.08	56
Trust Game Offer	272.5	105.18	149	280.4	122.7	56
Tutsi Selections	0.231	0.255	147	0.238	0.275	56
	Panel B: Outcomes - No Forced Labour Regions					
log(Default)	0.412	0.617	284	0.412	0.595	131
Income (USD)	273.77	522.59	280	211.21	374.06	127
Trust Game Offer	289.1	116.4	284	295.5	123.7	129
Tutsi Selections	0.185	0.231	284	0.234	0.267	131
	Panel C: Controls					
Gender: Female	31%	0.466	430	55%	0.499	187
Country: Burundi	0.619	0.486	430	0.594	0.492	187
Age	45.7	108.7	430	42.4	12.8	187
Education Years	5.7	3.4	429	6.2	3.8	187

Table 4.6.2: Effect of forced labour on interethnic trust

	Dependent variable: offer in trust game			
	Panel A: Hutu to Tutsi Offers			
	Difference-in-differences		Regression Kink	
	No cof. control	Cof. control	Cubic	Quintic
	(1)	(2)	(3)	(4)
Forced Labour x Eligible	-83.48	-82.86		
	(25.39)***	(25.27)***		
	[22.16]***	[21.94]***		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			-118.7	-127.7
			(29.38)***	(26.96)***
			[27.70]***	[28.10]***
Observations	191	191	191	191
R-squared	0.621	0.617	0.628	0.626
Grandparent Village Clusters	117	117	117	117
Bin (0.01) Clusters	44	44	44	44
	Panel B: Tutsi to Hutu Return Offers			
Forced Labour x Eligible	-27.32	-15.27		
	(48.52)	(59.79)		
	[52.28]	[53.43]		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			-53.25	-26.10
			(63.17)	(47.82)
			[79.45]	[57.40]
Observations	191	191	191	191
R-squared	0.585	0.583	0.582	0.593
Grandparent Village Clusters	117	117	117	117
Bin (0.01) Clusters	44	44	44	44
	Panel C: Hutu to Hutu Offers			
Forced Labour x Eligible	66.06	71.30		
	(63.79)	(64.10)		
	[57.78]	[57.32]		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			61.33	64.33
			(66.97)	(66.99)
			[61.98]	[62.10]
Observations	223	223	223	223
R-squared	0.523	0.525	0.533	0.533
Grandparent Village Clusters	107	107	107	107
Bin (0.01) Clusters	45	45	45	45

Notes: Standard errors in round brackets are clustered at the grandparent village level. Standard errors in square brackets are clustered at the treatment-bin level, with bins sized 0.01 of a unit of treatment. Controls include gender, age, age^2, grandparent country and interviewer fixed effects. *, **, *** represent significance at the 10%, 5%, 1% levels respectively. $\lambda \cdot$ Eligible $\cdot [\lambda > 1]$ represents the change in slope around the threshold, and is the variable of interest in the regression kink design.

Description: The table shows the estimates of the the effect of forced labour on interethnic trust. It identifies that forced labour decreased interethnic trust among Hutu but not generalized trust. The effect is not due to a Tutsi trustworthiness effect, since those not exposed to forced labour (Tutsi) do not treat other Tutsi different in forced labour regions.

Table 4.6.3: Effect of forced labour on partner selections

	Panel A: % Tutsi Chosen as Partner			
	Difference-in-differences		Regression Kink	
	No cof. control	Cof. control	Cubic	Quintic
	(1)	(2)	(3)	(4)
Forced Labour x Eligible	-0.0951	-0.0874		
	(0.0516)*	(0.0512)*		
	[0.0450]**	[0.0474]*		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			-0.348	-0.155
			(0.138)**	(0.0584)***
			[0.165]**	[0.0577]***
Observations	401	401	401	401
R-squared	0.453	0.453	0.332	0.466
Grandparent Village Clusters	181	181	181	181
Bin (0.01) Clusters	51	51	51	51
	Panel B: % High Income Chosen as Partner			
Forced Labour x Eligible	0.119	0.106		
	(0.103)	(0.106)		
	[0.104]	[0.110]		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			0.127	0.143
			(0.118)	(0.118)
			[0.105]	[0.106]
Observations	402	402	402	402
R-squared	0.388	0.388	0.392	0.397
Grandparent Village Clusters	182	182	182	182
Bin (0.01) Clusters	51	51	51	51
	Panel C: % Coffee Farmers Chosen as Partner			
Forced Labour x Eligible	-0.0681	-0.0393		
	(0.0944)	(0.0976)		
	[0.0737]	[0.0731]		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			-0.111	-0.122
			(0.101)	(0.103)
			[0.0858]	[0.0862]
Observations	402	402	402	402
R-squared	0.416	0.419	0.419	0.420
Grandparent Village Clusters	182	182	182	182
Bin (0.01) Clusters	51	51	51	51

Notes: Standard errors in round brackets are clustered at the grandparent village level. Standard errors in square brackets are clustered at the treatment-bin level, with bins sized 0.01 of a unit of treatment. Controls include gender, age, age^2, grandparent country and interviewer fixed effects. *, **, *** represent significance at the 10%, 5%, 1% levels respectively. $\lambda \cdot$ Eligible $\cdot [\lambda > 1]$ represents the change in slope around the threshold, and is the variable of interest in the regression kink design.

Description: The table shows that Hutu sort along ethnic lines but not along other lines which have been correlated with ethnicity. Hutu have had historically low income, but sorting does not occur based on class (defined as above or below the mean income level). Mistreated Hutu were also not more likely to sort along occupational lines, as they were not differentially more likely to choose to partner with another member of the coffee industry.

Table 4.6.4: Effect of forced labour on default

	Dependent Variable: *log*(*default*)			
	Panel A: Hutu subsample			
	Difference-in-differences		Regression Kink	
	No cof. control	Cof. control	Cubic	Quintic
	(1)	(2)	(3)	(4)
Forced Labour x Eligible	0.296	0.303		
	(0.0944)***	(0.0977)***		
	[0.0857]***	[0.0927]***		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			0.286	0.288
			(0.111)**	(0.112)**
			[0.0912]***	[0.0917]***
Observations	408	408	408	408
R-squared	0.290	0.291	0.300	0.301
Grandparent Village Clusters	187	187	187	187
Bin (0.01) Clusters	52	52	52	52
	Panel B: Tutsi subsample			
Forced Labour x Eligible	-0.325	-0.331		
	(0.212)	(0.214)		
	[0.198]	[0.200]*		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			-0.225	-0.240
			(0.228)	(0.226)
			[0.211]	[0.212]
Observations	178	178	178	178
R-squared	0.642	0.642	0.648	0.648
Grandparent Village Clusters	123	123	123	123
Bin (0.01) Clusters	52	52	52	52

Notes: Standard errors in round brackets are clustered at the grandparent village level. Standard errors in square brackets are clustered at the treatment-bin level, with bins sized 0.01 of a unit of treatment. Controls include gender, age, age^2, grandparent country and interviewer fixed effects. *, **, *** represent significance at the 10%, 5%, 1% levels respectively. $\lambda \cdot$ Eligible $\cdot [\lambda > 1]$ represents the change in slope around the threshold, and is the variable of interest in the regression kink design.

Description: This table shows that the expected increase in forced labour had little lasting impact on the contractual outcomes of Tutsi but did impact the contractual outcomes for Hutu. This is consistent with the idea that there is a causal link between trust and default, if it is true that forced labour caused a change in Hutu resentment, but no other factors relevant for default. Estimates with and without income controls are nearly identical, suggesting that the estimated effect is not operating through a direct income effect. Furthering this argument is the fact that historical income was reduced in a kinked pattern for both Hutu and Tutsi, but only Hutu that were exposed to forced labour experience more default.

Table 4.6.5: Effect of forced labour on ability based default

	Dependent Variable: *log*(*AbilityDefault*) Panel A: Hutu subsample			
	Difference-in-differences		Regression Kink	
	No cof. control	Cof. control	Cubic	Quintic
	(1)	(2)	(3)	(4)
Forced Labour x Eligible	0.431	0.442		
	(0.134)***	(0.141)***		
	[0.111]***	[0.117]***		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			0.456	0.460
			(0.193)**	(0.196)**
			[0.137]***	[0.138]***
Observations	408	408	408	408
R-squared	0.303	0.304	0.317	0.317
Grandparent Village Clusters	187	187	187	187
Bin (0.01) Clusters	52	52	52	52
	Dependent Variable: *log*(*AbilityDefault*) Panel B: Tutsi subsample			
Forced Labour x Eligible	-0.127	-0.130		
	(0.245)	(0.246)		
	[0.242]	[0.244]		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			0.118	0.0925
			(0.226)	(0.227)
			[0.225]	[0.222]
Observations	178	178	178	178
R-squared	0.603	0.603	0.612	0.613
Grandparent Village Clusters	123	123	123	123
Bin (0.01) Clusters	49	49	49	49
	Dependent Variable: *log*(*EffortDefault*) Panel C: Effort based defaults among Hutu			
Forced Labour x Eligible	0.0835	0.0841		
	(0.123)	(0.123)		
	[0.128]	[0.128]		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			0.0572	0.0743
			(0.144)	(0.149)
			[0.140]	[0.143]
Observations	408	408	408	408
R-squared	0.424	0.424	0.426	0.427
Grandparent Village Clusters	187	187	187	187
Bin (0.01) Clusters	52	52	52	52
	Dependent Variable: *Incentives* Panel D: Use of incentives among Hutu			
Forced Labour x Eligible	-0.0129	0.00323		
	(0.0495)	(0.0493)		
	[0.0468]	[0.0482]		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			0.0566	-0.0222
			(0.0702)	(0.0626)
			[0.0710]	[0.0552]
Observations	408	408	408	408
R-squared	0.347	0.354	0.352	0.363
Grandparent Village Clusters	187	187	187	187
Bin (0.01) Clusters	52	52	52	52

Notes: Standard errors in round brackets are clustered at the grandparent village level. Standard errors in square brackets are clustered at the treatment-bin level, with bins sized 0.01 of a unit of treatment. Controls include gender, age, age^2, grandparent country and interviewer fixed effects. *, **, *** represent significance at the 10%, 5%, 1% levels respectively. $\lambda \cdot$ Eligible $\cdot [\lambda > 1]$ represents the change in slope around the threshold, and is the variable of interest in the regression kink design.

Description: This table confirms that ability is the mechanism driving contractual default among Hutu whose grandparents were exposed to forced labour, consistent with evidence that these respondents draw partners from a more shallow talent pool. While ability is much more cited as the reason for default among those with a history of forced labour in both the difference-in-differences and RKD design, neither specification estimates any difference for effort based reasons or differences in the use of incentives.

Table 4.6.6: Effect of forced labour on income

	Dependent Variable: *log(income)*			
	Panel A: Hutu subsample			
	Difference-in-differences		Regression Kink	
	No cof. control	Cof. control	Cubic	Quintic
	(1)	(2)	(3)	(4)
Forced Labour x Eligible	-0.259	-0.261		
	(0.0579)***	(0.0595)***		
	[0.0419]***	[0.0417]***		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			-0.153	-0.150
			(0.0798)*	(0.0794)*
			[0.0578]***	[0.0568]***
Observations	419	419	419	419
R-squared	0.561	0.561	0.569	0.574
Grandparent Village Clusters	191	191	191	191
Bin (0.01) Clusters	52	52	52	52
	Panel B: Tutsi subsample			
Forced Labour x Eligible	0.105	0.101		
	(0.116)	(0.116)		
	[0.119]	[0.120]		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			0.173	0.178
			(0.106)	(0.110)
			[0.111]	[0.114]
Observations	178	178	178	178
R-squared	0.794	0.795	0.797	0.797
Grandparent Village Clusters	143	143	143	143
Bin (0.01) Clusters	49	49	49	49

Notes: Standard errors in round brackets are clustered at the grandparent village level. Standard errors in square brackets are clustered at the treatment-bin level, with bins sized 0.01 of a unit of treatment. Controls include gender, age, age^2, grandparent country and interviewer fixed effects. *, **, *** represent significance at the 10%, 5%, 1% levels respectively. $\lambda \cdot$ Eligible $\cdot [\lambda > 1]$ represents the change in slope around the threshold, and is the variable of interest in the regression kink design.
Description: This table shows that a family history of forced labour predicts income today for Hutu but not for Tutsi.

Appendix: Other Tables and Figures

Table 4.6.7: Effect of forced labour on the decision to migrate

	Different Village From Grandparents		Different Village From Parents		Time in Current Village	
	DiD	RKD	DiD	RKD	DiD	RKD
	(1)	(2)	(3)	(4)	(5)	(6)
Forced Labour x Eligible	0.0979		0.0136		-2.876	
	(0.0936)		(0.0795)		(3.039)	
	[0.0851]		[0.0703]		[2.406]	
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$		-0.0272		0.0461		-2.267
		(0.100)		(0.0890)		(3.291)
		[0.0935]		[0.0838]		[2.822]
Observations	603	418	594	410	601	416
R-squared	0.269	0.331	0.318	0.378	0.589	0.637
Grandparent Village Clusters	271	190	271	189	271	190
Bin Clusters (0.01)	66	54	66	54	66	54

Notes: Standard errors in round brackets are clustered at the grandparent village level. Standard errors in square brackets are clustered at the treatment-bin level, with bins sized 0.01 of a unit of treatment. Controls include gender, age, age^2, grandparent country and interviewer fixed effects. *, **, *** represent significance at the 10%, 5%, 1% levels respectively. $\lambda \cdot$ Eligible $\cdot [\lambda > 1]$ represents the change in slope around the threshold, and is the variable of interest in the regression kink design.
Description: This table shows that a family history of forced labour has little influence in migration decisions over multiple generations.

Table 4.6.8: McCrary Test for Sorting Around the Threshold

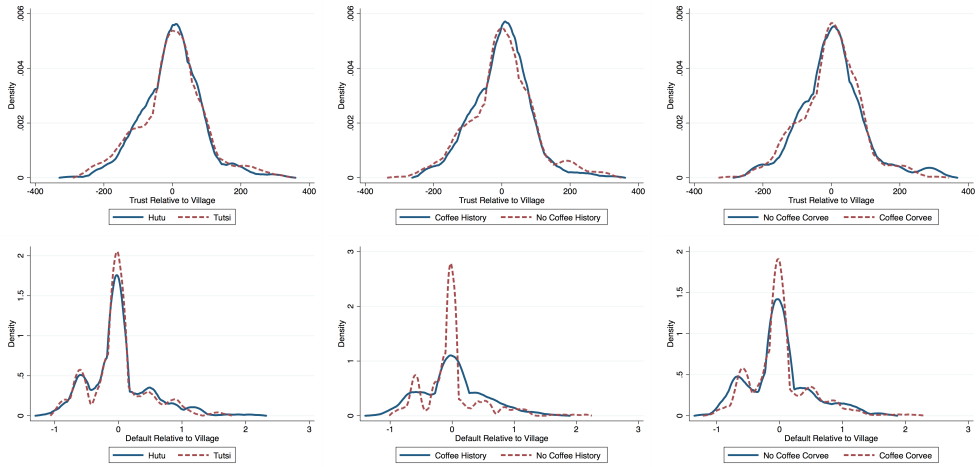
	Dep. Variable: Density (bins=0.01)			
	All		Hutu	
	(1)	(2)	(3)	(4)
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$	-33.98	-18.33	34.95	54.85
	(41.78)	(37.73)	(50.77)	(58.19)
	[40.71]	[34.18]	[29.28]	[32.05]*
λ Polynomial	Y	Y	Y	Y
$\lambda \cdot [\lambda > 1]$ Polynomial	Y	Y	Y	Y
Triple Difference Interactions	Y	Y	Y	Y
Village Fixed Effects	Y	Y	Y	Y
Controls	N	Y	N	Y
Observations	604	603	402	401
R-squared	0.465	0.495	0.574	0.605
Grandfather Village Clusters	263	263	184	184
Bin Clusters (0.01)	66	66	54	54

Notes: Standard errors are clustered at the grandparent village level. Controls include gender, age, age^2, country and interviewer fixed effects. *, **, *** represent significance at the 10%, 5%, 1% levels respectively. $\lambda \cdot$ Eligible $\cdot [\lambda > 1]$ represents the change in slope around the threshold, and is the variable of interest in the regression kink design.
Description: This table shows that there is no sorting around the kink threshold, which is the main identifying assumption associated with the RKD. This is not surprising given the nature of forced labour. There was no selection on land type prior to coffee forced labour because coffee was not an important crop in the region and the knowledge required to produce it was low. After the introduction of forced labour selection would be impossible, as chiefs and sub chiefs had a lot to gain by not allowing people to get out of their 'duties' and punishments for non-compliance were harsh.

Figure 4.6.1: McCrary Test for Sorting Around the Threshold

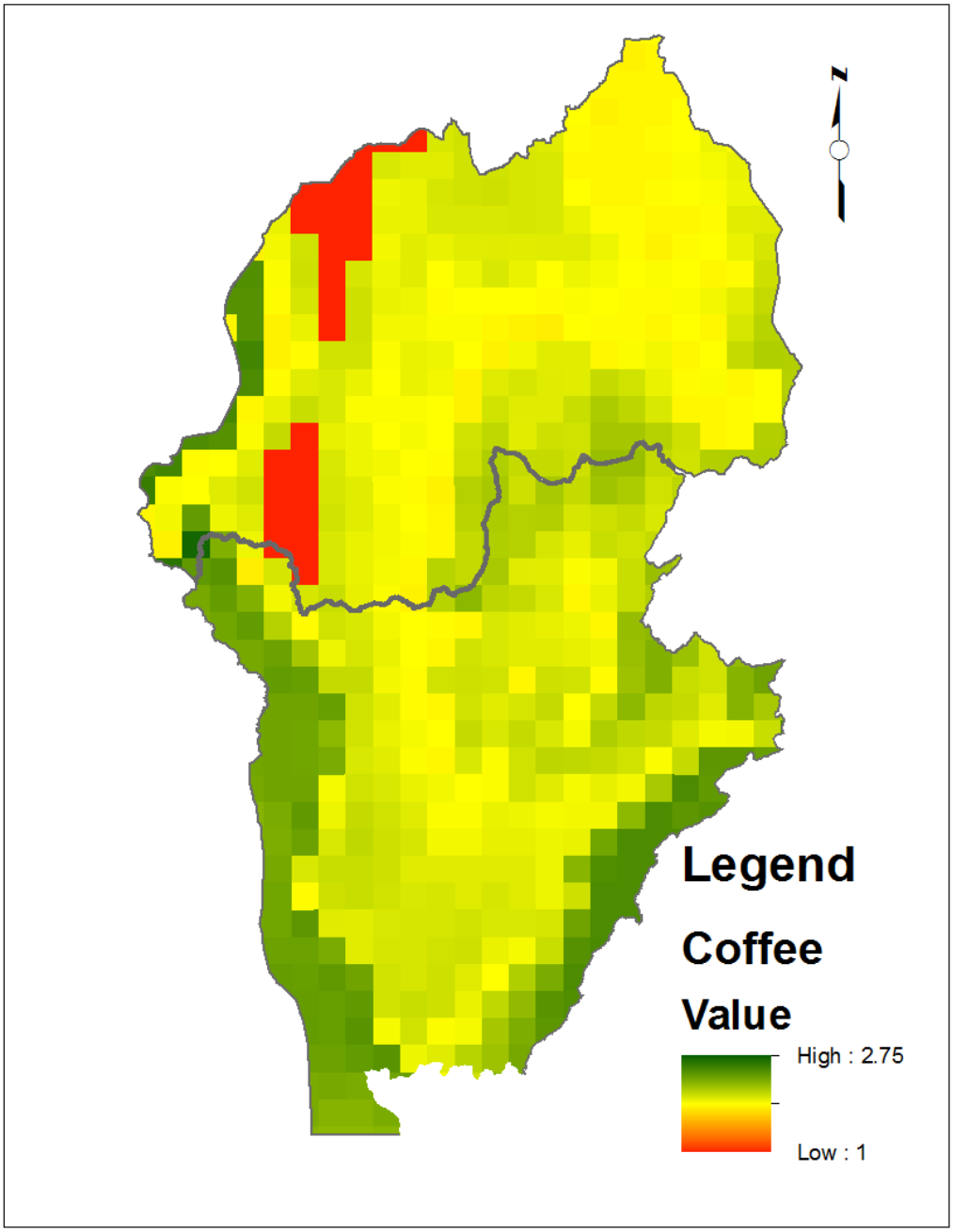
Description: This figure shows graphically that there was no sorting around the threshold. There is neither a discontinuity on either side of the threshold, nor a change in slope to the right of the threshold. This means that there was no selection from a coffee forced labour region to a non forced labour region and that there was no selection from a high forced labour region to a low forced labour region.

Figure 4.6.2: Differences in trust and default between ethnicities, coffee history and coffee suitability



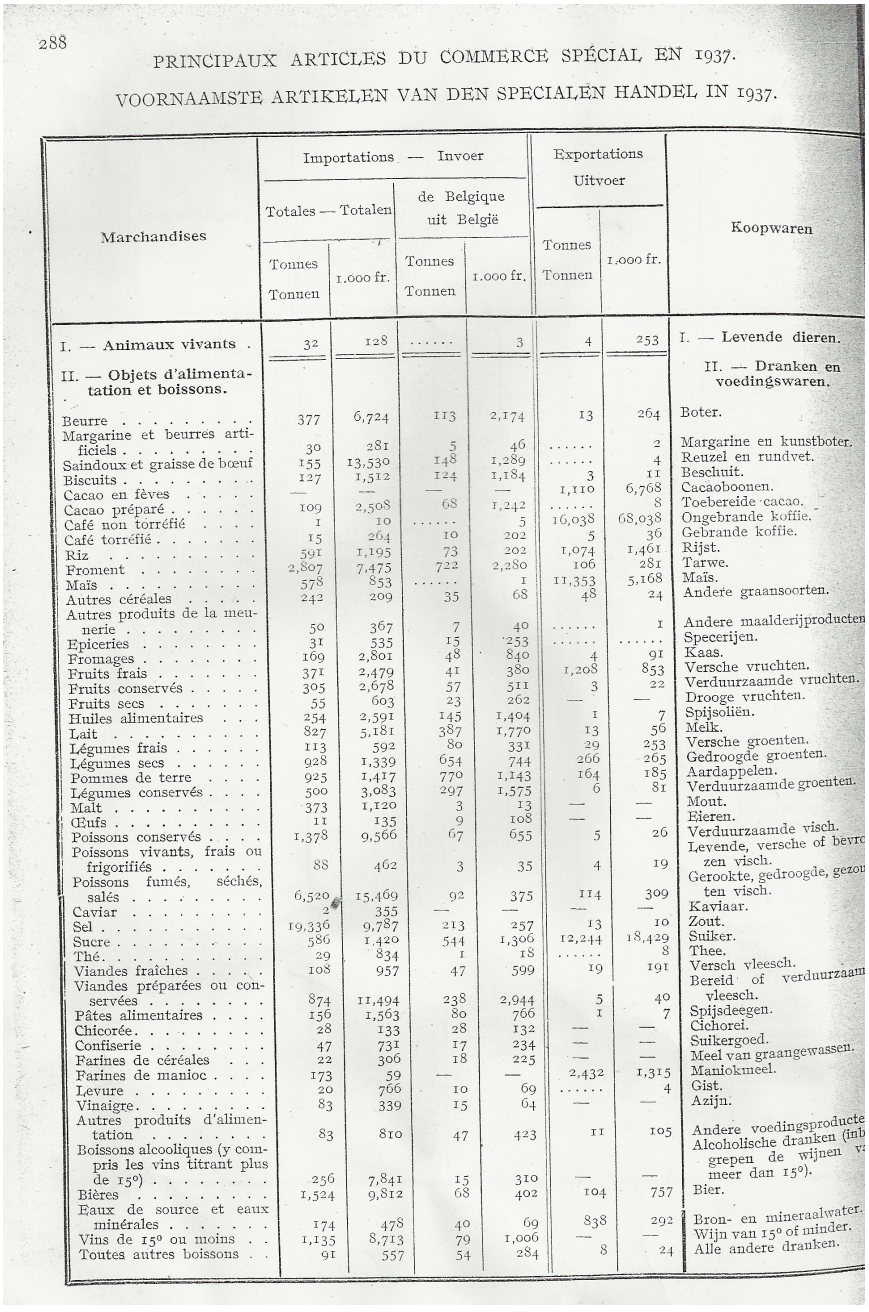
Description: These graphs show the distribution of the three main factors causing someone to be eligible for forced labour. Individually distributions are identical in each case meaning that unobservable differences in any particular factor are unlikely to be driving results.

Figure 4.6.3: Coffee Profitability



Description: This figure shows the growing potential of coffee and other relevant crops in Rwanda and Burundi in tonnes per hectare. Coffee is more robust to elevation than most other crops, which reflects the fact that the two largest forced labour regions were in the east where Manioc, cotton, etc. are profitable. Even in the mountains though potato is profitable so forced labour wasn't simply related to elevation.

Figure 4.6.4: One page of imports/exports section from 1937 list of goods produced in RwandaUrundi



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PRINCIPAUX ARTICLES DU COMMERCE SPÉCIAL EN 1937.

VOORNAAMSTE ARTIKELEN VAN DEN SPECIALEN HANDEL IN 1937.

Marchandises	Importations — Invoer				Exportations Uitvoer		Koopwaren
	Totales — Totalen		de Belgique uit België				
	Tonnes Tonnen	1.000 fr.	Tonnes Tonnen	1.000 fr.	Tonnes Tonnen	1.000 fr.	
I. — Animaux vivants	32	128	.....	3	4	253	I. — Levende dieren.
II. — Objets d'alimentation et boissons.							II. — Dranken en voedingswaren.
Beurre	377	6,724	113	2,174	13	264	Boter.
Margarine et beurres artificiels	30	281	5	46	.....	2	Margarine en kunstboter.
Saindoux et graisse de bœuf	155	13,530	148	1,289	.....	4	Reuzel en rundvet.
Biscuits	127	1,512	124	1,184	3	11	Beschuit.
Cacao en fèves	—	—	—	—	1,110	6,768	Cacaoboonen.
Cacao préparé	109	2,508	68	1,242	.....	8	Toebereide cacao.
Café non torréfié	1	10	.....	5	16,038	68,038	Ongebrande koffie.
Café torréfié	15	264	10	202	5	36	Gebrande koffie.
Riz	591	1,195	73	202	1,074	1,461	Rijst.
Froment	2,807	7,475	722	2,280	106	281	Tarwe.
Maïs	578	853	.....	1	11,353	5,168	Maïs.
Autres céréales	242	209	35	68	48	24	Andere graansoorten.
Autres produits de la meunerie	50	367	7	40	.....	1	Andere maalderijproducten
Epiceries	31	535	15	253	.....	.....	Specerijen.
Fromages	169	2,801	48	840	4	91	Kaas.
Fruits frais	371	2,479	41	380	1,208	853	Versche vruchten.
Fruits conservés	305	2,678	57	511	3	22	Verduurzaamde vruchten.
Fruits secs	55	603	23	262	—	—	Drooge vruchten.
Huiles alimentaires	254	2,591	145	1,404	1	7	Spijsoliën.
Lait	827	5,181	387	1,770	13	56	Melk.
Légumes frais	113	592	80	331	29	253	Versche groenten.
Légumes secs	928	1,339	654	744	266	265	Gedroogde groenten.
Pommes de terre	925	1,417	770	1,143	164	185	Aardappelen.
Légumes conservés	500	3,083	297	1,575	6	81	Verduurzaamde groenten.
Malt	373	1,120	3	13	—	—	Mout.
Œufs	11	135	9	108	—	—	Eieren.
Poissons conservés	1,378	9,566	67	655	5	26	Verduurzaamde visch.
Poissons vivants, frais ou frigorifiés	88	462	3	35	4	19	Levende, versche of bevro zen visch.
Poissons fumés, séchés, salés	6,520	15,469	92	375	114	309	Gerookte, gedroogde, gezou ten visch.
Caviar	2	355	—	—	—	—	Kaviaar.
Sel	19,336	9,787	213	257	13	10	Zout.
Sucre	586	1,420	544	1,366	12,244	18,429	Suiker.
Thé	29	834	1	18	.....	8	Thee.
Viandes fraîches	108	957	47	599	19	191	Versch vleesch.
Viandes préparées ou conservées	874	11,494	238	2,944	5	40	Bereid of verduurzaam vleesch.
Pâtes alimentaires	156	1,563	80	766	1	7	Spijsdeegen.
Chicorée	28	133	28	132	—	—	Cichorei.
Confiserie	47	731	17	234	—	—	Suikergoed.
Farines de céréales	22	306	18	225	—	—	Meel van graangewassen.
Farines de manioc	173	59	—	—	2,432	1,315	Maniokmeel.
Levure	20	766	10	69	.....	4	Gist.
Vinaigre	83	339	15	64	—	—	Azijn.
Autres produits d'alimentation	83	810	47	423	11	105	Andere voedingsproducte
Boissons alcooliques (y compris les vins titrant plus de 15°)	256	7,841	15	310	—	—	Alcoholische dranken (inb grepen de wijnen v meer dan 15°).
Bières	1,524	9,812	68	402	104	757	Bier.
Eaux de source et eaux minérales	174	478	40	69	838	292	Bron- en mineraalwater.
Vins de 15° ou moins	1,135	8,713	79	1,006	—	—	Wijn van 15° of minder.
Toutes autres boissons	91	557	54	284	8	24	Alle andere dranken.

Table 4.6.9: The impact on the Rwandan genocide, and the robustness to this effect

	Panel A: Classic RKD specification log(genocide violence per person)			
	Cat 1	Cat 2	Cat 3	
	(1)	(2)	(3)	(4)
$\lambda \cdot [\lambda > 1]$	0.0432	0.0856	0.0807	
	[0.0203]**	[0.0342]**	[0.0331]**	
Observations	276	276	276	
R-squared	0.181	0.161	0.125	
	Panel B: Burundi Only Sample Hutu to Tutsi trust game offer			
FLIntensity x Eligible	-72.84***	-70.27***		
	(23.32)***	(24.26)***		
	[16.61]***	[17.47]***		
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$			-92.60	-80.86
			(26.10)***	(26.10)***
			[28.08]***	[28.08]***
Observations	207	207	207	207
R-squared	0.398	0.421	0.457	0.460
Grandparent Village Clusters	131	131	131	131
Bin (0.01) clusters	46	46	46	46

Notes: Standard errors are clustered at the grandparent village level in columns 4 and 5. Heteroskedasticity robust standard errors are included in columns 1, 2, 3. In column 1, 2, 3 the unit of observation is a geographic cell in Rwanda . In columns 4 and 5 a unit of observation is a lab game respondent in Burundi. Controls include gender, age, age^2, country and interviewer fixed effects. *, **, *** represent significance at the 10%, 5%, 1% levels respectively. $\lambda \cdot$ Eligible $\cdot [\lambda > 1]$ represents the change in slope around the threshold, and is the variable of interest in the regression kink design.
Description: The table shows that while historic forced labour is associated with more genocide violence, it is not confounding estimates. Columns 1, 2 and 3 show the effect of forced labour on different categories of violence, with category 1 being the most serious crimes, and category 3 being relatively less serious. Columns 4 and 5 show that the estimates do not operate through the genocide by restricting the sample to Hutus in Burundi. In Burundi there was no genocide, so it could not be influencing estimates in this sample. The estimates are similar to the estimates in the full sample and remain significant at the 1% level. This implies that the village fixed effects in the full sample do a reasonably good job of capturing the impact of the genocide on trust.

Table 4.6.10: Differences in trust for the relative profitability of crops other than coffee

Other Crops:	Manioc (1)	Cotton (2)	Sugarcane (3)	Rice (4)	Banana (5)
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$	-2x10^{-6} (6x10^{-6}) [6x10^{-6}]	3x10^{-6} (2x10^{-6}) [3x10^{-6}]	2x10^{-6} (3x10^{-6}) [3x10^{-6}]	2x10^{-6} (2x10^{-6}) [3x10^{-6}]	3x10^{-6} (2x10^{-6}) [2x10^{-6}]
λ Polynomial	Y	Y	Y	Y	Y
$\lambda \cdot [\lambda > 1]$ Polynomial	Y	Y	Y	Y	Y
Triple Difference Interactions	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y
Village Fixed Effects	Y	Y	Y	Y	Y
Observations	256	256	256	256	256
R-squared	0.561	0.580	0.562	0.560	0.556
Grandparent village clusters	131	131	131	131	131
Bin clusters (0.01)	46	46	46	46	46

Notes: Standard errors are clustered at the grandparent village level. Controls include gender, age, age^2, country and interviewer fixed effects. *, **, *** represent significance at the 10%, 5%, 1% levels respectively. $\lambda \cdot$ Eligible $\cdot [\lambda > 1]$ represents the change in slope around the threshold, and is the variable of interest in the regression kink design.
Description: This table shows that there is something unique about the coffee industry, and it results are not driven by factors associated by market dominance in any particular industry. It rejects the idea that low trust may be associated with intensity of production because when production is very homogeneous, the benefits of diverse networks may decrease. Coffee is the only crop for which regional suitability dominance implies lower trust.

Table 4.6.11: Differences in current location rather than historical family location for trust and default

	Trust Game Offer			log(Default)		
	(1)	(2)	(3)	(4)	(5)	(6)
$\lambda \cdot$ Eligible $\cdot [\lambda > 1]$	3x10^{-7} (2x10^{-7}) [3x10^{-7}]	2x10^{-7} (4x10^{-7}) [4x10^{-7}]	5x10^{-6} (6x10^{-6}) [6x10^{-6}]	1x10^{-9} (8x10^{-10}) [10x10^{-10}]	8x10^{-10} (5x10^{-9}) [5x10^{-9}]	9x10^{-10} (7x10^{-10}) [9x10^{-10}]
λ Polynomial	Y	Y	Y	Y	Y	Y
$\lambda \cdot [\lambda > 1]$ Polynomial	Y	Y	Y	Y	Y	Y
Triple Difference Interactions	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Grandfathers Village Fixed Effects	Y	Y	Y	Y	Y	Y
Observations	262	196	78	419	181	600
R-squared	0.821	0.803	0.872	0.777	0.937	0.752
Grandparent village clusters	85	75	35	87	57	103
Bin clusters (0.01)	52	44	39	52	50	63

Notes: Standard errors are clustered at the village level. Controls include gender, age, age^2, country and interviewer fixed effects. *, **, *** represent significance at the 10%, 5%, 1% levels respectively. $\lambda \cdot$ Eligible $\cdot [\lambda > 1]$ represents the change in slope around the threshold, and is the variable of interest in the regression kink design.
Description: This table shows that there is something unique about family history during the forced labour era. While it seems unlikely that current location would be driving the main results due to village fixed effects, this table confirms that there are no interaction type effects driving results.

5
Conclusions

This dissertation has outlined the importance of culture and economic relationships for the development process. Chapter 2 showed that insular cultures have a reduced capacity to adopt technologies, chapter 3 outlined some causes and consequences of low relationship values, and chapter 4 analyzed the origins and economic consequences of low trust.

This area of research is growing, but far from complete. The importance of a number of different related questions have become apparent, and these issues will be dealt with in future works. One clear question is whether policy can influence cultural outcomes in the short run. It is clear from chapter 4 that policy can influence culture over the long-term, but if culture is very slow moving, then there may not be incentives for leaders to influence policy. If however, culture can be shifted within a leaders term, then culture plausibly influences the re-election of policy makers, and the implications of this could be significant.

A number of projects are currently underway to address this issue:

The first, a project underway (with Mukand and Majumdar) examines national

versus tribal identity following colonial independence in Africa. Preliminary results show that nationalistic policies are much more influential on contemporary national identity immediately after independence, than contemporary policy. Once a identity is established it is very difficult to change.

On the other hand, evidence from Rwanda (with Mukand) shows that discrimination in Rwanda may have been influenced in the short-run after the genocide. Paul Kagame implemented immediate social policies aiming to make mentions of Hutu/Tutsi taboo. As a result, ethnicity is not currently discussed in Rwanda. Reconciliation, at least on the surface, seems to have taken place faster than after any other large episode of violence throughout history. Data has been collected with the intention of analyzing post-genocide reconciliation, another avenue for future research that seems promising.

Another promising avenue for future work is investigating other consequences of low trust. Using unique and detailed coffee washing station data (with Macchiavello and Morjaria) preliminary results show a large negative correlation between marginal costs and general trust. This could be the result of cooperation between stations. This would provide some of the first firm level evidence on the reasons why low generalized trust influences economic activity.

These projects all contribute to the literature examining the relationship between culture and economic relationships. They investigate the origins of trust and show why history influences current economic outcomes through culture. It is currently unclear how culture changes over time, and this is a pressing concern for future work. But the work presented in this dissertation has hopefully underscored the importance of both culture and relationships for economic development, and has has hopefully advanced current understanding of how and why these factors are so important.

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